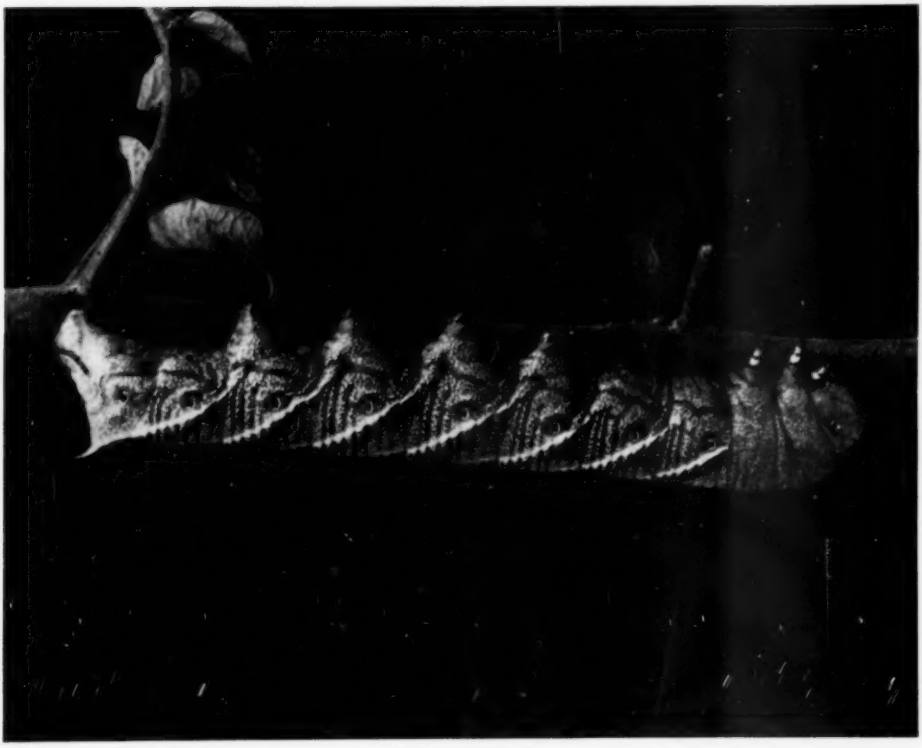
The Control of Diseases and Insects Affecting Vegetable Crops

By CHARLES CHUPP and R. W. LEIBY



Tomato Worm

CORNELL EXTENSION BULLETIN 206 • FEBRUARY 1931
REVISED JULY, 1953

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THE CONTROL OF DISEASES AND INSECTS AFFECTING VEGETABLE CROPS

By CHARLES CHUPP and R. W. LEIBY

THIS BULLETIN brings together all the more pertinent facts concerning the practical control of the insects and diseases that affect the important vegetable crops in New York State. Much of this material has been published in bulletins or elsewhere but is available only to those who have access to a large agricultural library. Considerable additional information has been obtained from unpublished material of the research workers of the state experiment stations.

ASPARAGUS

ASPARAGUS BEETLES

Two kinds of beetles (*Crioceris asparagi* Linnaeus and *C. duodecimpunctata* Linnaeus) that are closely related attack asparagus. One is known as the *12-spotted asparagus beetle,* the other as the *common asparagus beetle.* Both are about ¼ inch in length, and both have similar greenish slugs as their active immature stage. Both beetles and the slug stages cause injury to asparagus as they feed upon its foliage, flowers, fruit, and stems.

The most serious injury is the defoliation which results from the larvae feeding on the foliage in summer, because this causes the rootstocks to produce weak and fewer eyes for the crop to be cut the following spring. In some seasons the number of overwintering beetles that survive is great enough to spoil the appearance of cut asparagus by their feeding upon the new tender shoots before they are cut.

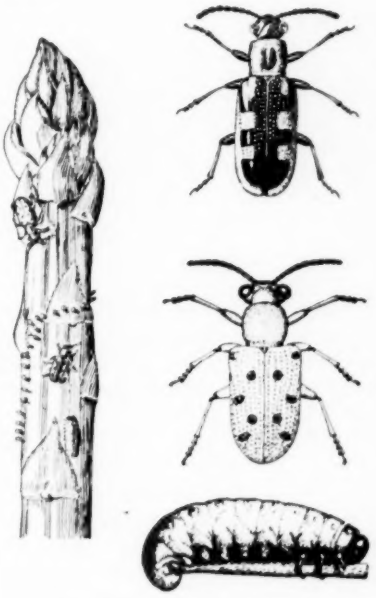


FIGURE 1. ASPARAGUS BEETLES

Left: egg, larva, and beetles on an asparagus tip. *Right:* two kinds of asparagus beetles and a larva

Control

Injury to the tender uncut tips in spring may be prevented if the crop is cut clean every three to five days. A ¾ of 1 per cent

rotenone dust kills the beetles; but, if this dust is used heavily on the uncut tips, it may be advisable to wash off the dust residue before the tips are marketed. This same dust is effective against the larvae or grubs if their bodies are well covered with the dust. An 85-15 calcium-arsenate–hydrated lime dust is equally effective, but this should be used only on the foliage of young asparagus that is not old enough to cut, or on the summer foliage of older asparagus. Never should the arsenate dust be applied to the tips that are being harvested. A pyrethrum dust also is effective.

A rotenone spray may be used in place of a dust. It is prepared by mixing 4 pounds of a rotenone powder containing 4 per cent rotenone in 100 gallons of water and adding a suitable spreading agent to it so that the rotenone spray will wet the asparagus and the insects. A commercial synthetic spray containing rotenone or pyrethrum extract also is effective. The sprays against this insect are somewhat superior to the dusts, for at average or high pressures they cause the slugs to loosen their hold on the foliage and to fall to the ground, whereupon a goodly number fail to get back onto the foliage and die.

RUST

At present there are no serious diseases of asparagus. Rust (caused by *Puccinia asparagi*) may be present occasionally. The bushy tops of the plants become covered with reddish or black pustules. This prevents the normal manufacture of food and its storage in the roots, thus decreasing the succeeding season's yield. The rust overwinters mostly in the form of teliospores that can cause infection of the young shoots in the spring. The rust fungus thrives best where there are few dashing rains but where dew or fog is prevalent. Dry soils are favorable for its development.

Control

It is advisable to burn the diseased tops late in the fall. In Illinois, instead of burning, a dormant application of a 1 per cent Elgetol solution, from 600 to 800 gallons an acre, applied at a pressure of 400 pounds, reduced somewhat the spring stage of the fungus. The spray can be put on the old plants either in the fall or the spring. During the cutting season, all plants should be kept cut. Only resistant varieties should be planted. Among these, Palmetto and Argenteuil are fairly safe. The most resistant ones, however, are Mary Washington and Martha Washington, which are being used generally in New York. A few of the Washington strains put on the market are not fully resistant. A selection known as *Paradise* proved very susceptible under New York conditions. Care should be taken therefore in getting truly resistant strains, and spraying will not be required. Apparently in Illinois a new strain of the rust has appeared, for no varieties proved resistant when tested in that State.

BEANS

SNAP BEANS, field dry beans, and lima beans are attacked by the seed corn maggot as they sprout in the ground. The growing plants may be injured by flea beetles, the Mexican bean beetle, the potato leafhopper, aphids, and mites. When bean seed is stored under room temperatures it is likely to be destroyed by the bean weevil.

The degree of injury caused by one or more of these pests varies each year, depending also on the kind of beans grown and on the area in which they are grown. The control of these bean pests, except for the maggot, is discussed from the standpoint of the kind of crop grown.

SEED CORN MAGGOT

In years of excessive rainfall during May and early June, growers of field dry beans,

snap beans, and lima beans are likely to experience heavy losses from the destruction of the germinating seed by the seed corn maggot (*Hylemyia cilicrura* Rondani). Sometimes an entire field is so badly injured that the crop has to be abandoned and the land refitted for some other crop. This degree of injury may result also when beans are planted so that they sprout when a generation of maggots is active.

The flies of the seed corn maggot are similar to those of the cabbage root maggot. They are attracted to newly plowed land, where they deposit their eggs in the soil. They prefer moist soil for egg-laying, and the eggs are usually placed near decaying vegetation. Soil containing the decaying roots of clover and alfalfa is especially attractive to the flies for egg laying.

The eggs hatch in from two to four days and from them small white maggots emerge. These make their way to the decaying vegetable matter upon which they feed and develop, or to sprouting bean plants which are injured when the maggots burrow into the small bud between the two halves of the seed. If this bud is destroyed, the plant comes up in a deformed condition and the injured plant is known as a *snakehead* or *baldhead*. Injured plants are stunted and die.

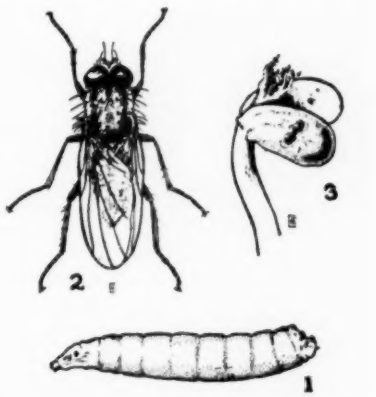


FIGURE 2. THREE STAGES OF THE SEED CORN MAGGOT

1, maggot stage that attacks sprouting beans; 2, adult, or fly stage; 3, injured sprouting bean

Control

By Timing Plantings

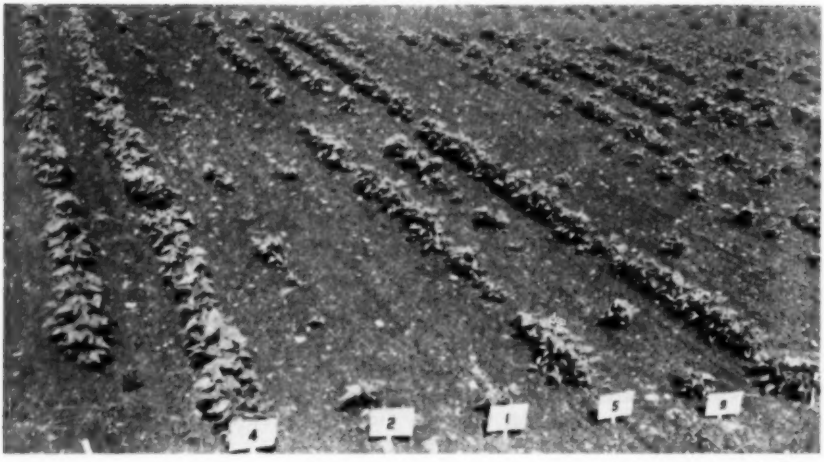
Much of the injury may be prevented by fitting the soil properly and by planting at such a time that the bean seed will not be sprouting while a brood of maggots is developing.

Because flies are attracted to freshly plowed soil, it is always best to plow and fit it in April or early May before the flies become abundant. Early fitting often results in a dry top layer of soil and as a result the number of eggs deposited will be reduced greatly. The addition of barnyard manure to a field just before planting also attracts the flies because of the tendency of the manure to hold moisture; therefore, it is better to apply the manure to some other crop in the rotation and to use instead a commercial fertilizer.

Shallow planting so that the beans come up quickly also helps to prevent maggot injury. Slow-sprouting beans in cool wet weather encourages the injury. Shallow planting is best done by using a bean planter, for a drill is likely to plant the seed too deep in the soil.

For lima and dry beans, the timing of planting to prevent maggot injury is of utmost importance in up-state New York. In some seasons it appears safe to plant beans almost any time, but in most seasons planting can be done too soon or too late, and sprouting may take place during the time maggots are active in the soil, with disasterous results. The safe and recommended dates for the past few years in counties on and near Lake Ontario have been: 1938, June 6; 1939, June 12; 1940, June 5; 1941, June 3; 1942, June 6; 1943, June 10; 1944, May 29; 1945, June 13; 1946, June 11; 1947, June 16; 1948, June 11; 1949, June 7; 1950, June 9; 1951, June 8–12; and 1952, June 11–15.

Because these dates vary with an early or a retarded season, the optimum time



Photograph by W. L. Howe

FIGURE 3. FIELD TRIALS WITH FORDHOOK LIMA BEANS, SHOWING THE NECESSITY OF USING A FUNGICIDE WITH THE INSECTICIDE

Reading from left to right, (4) Dieldrin plus Arasan, (2) Arasan alone, (1) no treatment, (5) Dieldrin alone, (9) Lindane alone, (next row) Lindane plus Arasan

of planting varies. Information on the development of this insect in the field each spring is supplied to county agricultural agents, from whom growers can get the planting dates that are advised as a way to prevent serious injury.

Insecticides Coated on the Seed

Experiments conducted by workers[1] at the agricultural experiment station at Geneva during the past several years have shown that good control of the seed corn maggot can be procured by coating dry bean and lima bean seed with an insecticide and fungicide before planting. With such treatment, bean seed may be planted at times when the maggots are present and planting need not be delayed until the maggot-free dates.

The seed is first suspended in a spreader-sticker solution composed of 4 per cent Methocel. The fungicide and insecticide then adhere to the smooth seed covering.

The insecticide mixtures listed in the table on page 9 were tested sucessfully in the field in 1950, 1951, and 1952.

Preparation of coating mixture

To make 3 gallons of a 4 per cent methocel solution, 1 pound of Methocel (methyl cellulose 15 c. p. s. viscosity type) is used. Both fibre and powdered forms are available, the fibre type going into solution in cold water in 24 hours.

To make 1 gallon of methocel solution, add ⅓ pound of methocel to 1 quart of hot water. Stir the mixture and allow it to soak for 20 to 30 minutes. Add 3 quarts of cold water and stir until smooth. Cool. Store in containers with tight-fitting lids.

A slurry of the Methocel and insecticide and fungicide is then made by mixing thoroughly the insecticide and fungicide when dry and then adding the 4 per cent Methocel solution. Stir until smooth.

The seed to be treated is then placed in a flattened pile on smooth flooring or on a tarpaulin. The slurry mixture is

[1]The following discussion on the coating of seed beans with an insecticide to control the seed corn maggot has been prepared from notes supplied by W. L. Howe and W. T. Schroeder of the New York State Agricultural Experiment Station at Geneva.

Wettable powder of insecticide	Ounces per bushel of seed	Fungicide	Ounces per bushel of seed	4 per cent methocel solution per bushel of seed
Lindane 25 per cent	1	Arasan SF	1.3	½ pint
Dieldrin 25 per cent	1	Arasan SF	1.3	½ pint
Chlordane 50 per cent	1	Arasan SF	1.3	½ pint

poured over the seed at the rate of 8 fluid ounces for each bushel of seed. (Small bean seed with a greater total seed coat area per unit volume may be treated with slightly increased amounts of slurry mixture up to 10 to 12 ounces per bushel. The dosage for Fordhook lima beans should not be increased). The seed should be raked immediately to distribute the slurry with occasional shoveling to turn the seed over in the bottom of the pile. Stirring should continue until the seeds are dry. With good air circulation, a batch of seed may be treated in 15 to 20 minutes.

It is also the experimental evidence of Dr. H. C. Huckett, working at the Long Island Experiment Station at Riverhead that, at least under his conditions, a high degree of maggot control on lima beans is not always evident when the seed is coated with an insecticide prior to planting. The same is true when the insecticide is included in the row or in the fertilizer at the time of planting.

Not a few bean growers have used this seed coating method to procure better bean stands in the past few years. Some have found that by using a proprietary mixture of the insecticide and fungicide containing a wetting agent, they can cause enough of the powder mixture to adhere to bean seeds with the aid of a little water. Others simply mix the beans in a dry dust mixture. On the basis of experimental evidence available, a grower should probably follow one of the recommended treatments only.

Prepared slurrys are now available at insecticide dealers. Label directions should be followed when treating the beans.

FLEA BEETLES

Several kinds of beetles from about ⅛ to $^{3}/_{16}$ inch long sometimes feed upon bean seedlings to the point where their control is necessary. They are known as the pale-striped flea beetle *(Systena taeniata* Say) and the red-headed flea beetle *(Systena frontalis* Fabr.). A related insect known as the bean leaf beetle *(Cerotoma trifurcata* Forster) is even more destructive at times than the true flea beetles.

One or more of these beetles may appear in quite destructive numbers in a field because it developed upon some other crop grown in the field during the previous season.

These insects pass the winter in their adult stages while hiding in trash. Their immature stages develop as they feed upon the roots of bean or other plants. The control of these beetles is discussed on page 25. They are readily killed by rotenone or DDT.

MEXICAN BEAN BEETLE

The Mexican bean beetle *(Epilachna varivestis* Mulsant) is now widely distributed throughout the State. In some seasons it is especially injurious to snap beans in the Hudson and Mohawk Valleys, in counties where canning beans are grown, and in the southern tier and adjacent counties on field-grown dry beans. In all these districts the beetle must be watched closely and control measures must be applied when injury is threatened.

Habits of Beetle and Grub

The beetles presumably pass the winter under trash and the debris found com-

monly about back yards and hedgerows. They appear in June on beans, and lay clusters of 20 to 50 orange-colored eggs on the lower surface of the foliage. The eggs hatch in ten days and produce spiny lemon-yellow grubs which feed for the most part on the lower surface of the beans. In about three weeks after the grubs come out of their egg stage, they are fully grown and ready to assume the resting or pupal stage which extends over a week or ten days. At the end of this period, the first brood of beetles appears and clusters of eggs are deposited in August to begin a second brood of grubs and beetles. Beetles of the latter crop are the ones that pass the winter.

There are two peak periods of injury during the growing season. The first is caused by the feeding of the first crop of grubs during the month of July. A later period of extensive feeding is in late August. It is at these periods when from one to three applications of an insecticide may be necessary to check the possible damage.

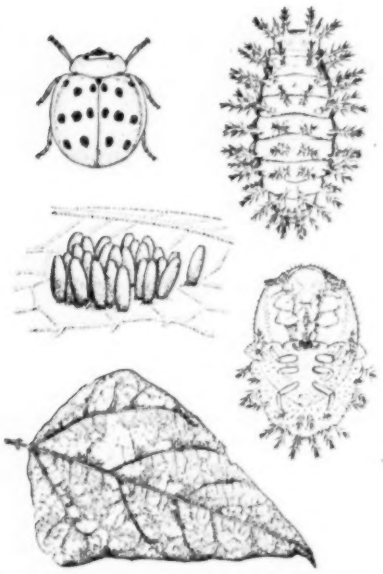


FIGURE 4. STAGES OF THE MEXICAN BEAN BEETLE AND INJURY TO FOLIAGE

Top: left, beetle; *right,* spiny grub, or larva. *Center: left,* mass of eggs; *right,* pupa partly within the larval skin. *Bottom,* typical injury to a bean leaf caused by the beetle and its grub

LEAFHOPPERS

Leafhoppers are tiny greenish insects that suck the plant juices as they feed on the lower surface of bean leaves. They may be present in their winged adult form or in their immature wingless form. Their feeding causes the foliage of dry beans to cup downward umbrella-shaped.

Field tests have indicated that where an average of three adult or immature leafhoppers are present per plant control measures are profitable, especially on dry and snap beans. This is true particularly if the plants are 6 inches or less in height.

Leafhoppers are readily killed by the DDT in a rotenone-DDT spray or dust or by parathion used to control the bean beetle as described on pages 12 to 14.

MITES

Several kinds of tiny spider-like animals known as *mites* develop at times on the underside of bean leaves and cause severe injury by their feeding unless they are controlled. This is particularly true on the lima-bean crop grown on Long Island. Instances have been observed also where severe injury was caused by mites feeding on dry-bean foliage.

Continued feeding by mites causes the leaves and lima-bean pods to assume a rusty appearance. A fairly severe infestation may throw lima beans out of grade because they have lost their green color.

Mites are readily killed by dusts or sprays or parathion or TEPP and by other related insecticides. Their control is discussed on pages 12 to 14.

APHIDS

Several kinds of aphids appear at times on bean foliage in numbers to cause injury. This is particularly true of the bean aphis (*Aphis rumicis* L.) when it is present

FIGURE 5. BEAN PLANT INJURED BY LARVAE OF THE MEXICAN BEAN BEETLE

in some numbers on the flower stalks of lima beans. Another kind of aphis found usually on small bean plants is the melon aphid (*Aphis gossypii* Glover).

The bean aphids suck plant juices from the leaves to weaken the plants. They are readily killed by parathion. TEPP, or nicotine sprays or dusts as described on pages 29 to 30.

BEAN WEEVIL

Garden-grown beans when put in winter storage often are infested and destroyed by the grub stage of the bean weevil (*Bruchus obtectus* Say). The infestation usually starts in mature and dry beans in split pods just before they are harvested, when a few weevils lay eggs in the exposed beans. These eggs produce small grubs that mature to weevils within the beans. Field-grown beans seldom are bothered seriously by this pest. When the moderately infested beans are harvested and stored in a reasonably warm place, the infestation builds up with other generations of weevils and the entire stored crop may be ruined completely in a few months.

Control

All stages of this insect are readily killed by dry heat, hence an infestation can be prevented or eliminated if the beans are placed in an oven in which the temperature is raised to 130° F. and kept there for 30 minutes at that temperature. This is best done right after the beans are considered dry and before they are to be stored. Following this treatment, the beans should be placed in tight containers to exclude weevils as a means of preventing a reinfestation. This treatment is for beans that are to be eaten and not for beans

to be kept for planting another season, for the heat used in the treatment may prevent sprouting.

Large quantities of beans and seed beans may be fumigated with carbon bisulfide. In this treatment 1 liquid ounce of this fumigant is poured over each bushel of beans after they have been placed in a tight box or barrel or in a receptacle from which the fumes cannot escape. The carbon bisulfide may also be placed in a shallow dish, such as a pie tin, which is then placed on top of the beans. The fumigating chamber must then be covered tightly and kept closed for from twenty-four to thirty-six hours. To be effective the treatment must be given while the beans are in a temperature of 70° F. or higher. Carbon bisulfide and its fumes are inflammable, and an explosion is likely if fire of any kind is brought in proximity to the fumes. It is even dangerous to switch on an electric light in the presence of the fumes. Smoking is most dangerous.

A 3 per cent DDT dust mixed at the rate of ½ ounce to each bushel of beans is effective in preventing weevil injury. This dust should be used only on seed beans and not on beans that are to be eaten by humans.

Weevil infested or injured beans should never be used for seed, for the percentage of germination will be low and those that do sprout are not likely to produce thrifty plants.

FOLIAGE INSECT CONTROL ON LIMA BEANS

The entire insect complex is troublesome or destructive to the foliage of the lima-bean crop grown under Long Island conditions each year. Elsewhere all of the insects except mites and aphids usually need to be controlled.

When beans are planted prior to June 5 on Long Island and prior to June 15 in up-state New York, control of the maggot should be considered. The seed may be treated with a fungicide and an insecticide as described for maggot control on page 8.

On Long Island it appears best to apply an insecticide to the growing plants that will control all insects that attack the foliage. Growers have found that a spray of 1½ pounds of wettable powder of parathion or 1 pint of a 25 per cent emulsion of parathion to 100 gallons of water, or TEPP at manufacturers' directions will control all bean insects. A related insecticide known as Metacide is also effective. A new insecticide as malathon is also good for bean insects when used at the rate of 1 quart of the 50 per cent emulsion to 100 gallons of water. The latter spray can be used with more safety to the spray operator.

Those who depend upon dusts can use effectively a 1 per cent parathion, or 1 per cent TEPP, or a 5 per cent malathon dust. Either should be used at the rate of 35 to 40 pounds per acre.

It is best to plan to make three or four treatments on Long Island at regular intervals, beginning when the bean beetles first appear on the growing beans. An earlier treatment may be needed when the beans are small if they are being injured by flea beetles; a rotenone or a DDT or a parathion dust or spray is also effective at this time.

Under up-state conditions the most important pests of lima beans are the maggot, the bean beetle, and leafhoppers, although several kinds of flea beetles are sometimes injurious to the bean plants when they are in the two-leaf stage.

On this crop, the seed corn maggot must be controlled as described on page 7. The flea beetles may also need a control treatment with rotenone, DDT or parathion.

The Mexican bean beetle and leafhopper can be controlled by a spray or dust as described above for Long Island conditions. A very effective and commonly used substitute for up-state conditions for these two insects is a combination dust of ¾ per cent rotenone plus 2 per cent DDT, or a 1 per cent parathion plus 2 per cent DDT. Substitute sprays for these

dusts are 3 pounds of 4 per cent rotenone powder plus 2 pounds of 50 per cent wettable powder of DDT to 100 gallons of water, or 1 pound of 15 per cent wettable powder of parathion plus 2 pounds of 50 per cent wettable powder of DDT to 100 gallons of water. One-half or 1 pint of parathion emulsion or of TEPP may be substituted for the parathion wettable powder, and 1 quart of 25 per cent DDT may be substituted for the 2 pounds of wettable powder of DDT. Malathon may also be used.

FOLIAGE INSECT CONTROL ON DRY BEANS

The foliage of the field or dry bean crop grown in up-state New York is attacked by the same insects as described for the up-state–grown lima-bean crop. The maggot must be controlled by delaying planting until the maggot-free period. When it is desired to plant before about June 10, an insecticide and a fungicide should be used as described on pages 8 and 9. The bean beetle must be controlled in most years and in most areas as described for up-state grown lima beans (page 12).

When the bean beetle is present in destructive numbers, as it was in 1949, 1950, and in 1951, most growers must be prepared with insecticides and suitable spray or dusting machinery to combat it. A grower who is not dependent on a custom control operator can control the bean beetle with one thoroughly applied treatment exactly timed. Those who depend upon somewhat inefficient equipment, upon aircraft treatments, or upon the too often tardy applications of custom control operators should plan to make two treatments. The control is directed against the overwintering brood of beetles or against the first brood of larvae. It is practised sometime between July 10 and 20 in average years. It does not appear profitable to control the second brood of spiny slugs in early September because the beans are approaching maturity; moreover, the bean fields are often grassy or weedy to the point where the effectiveness of the insecticides is materially lessened.

The first treatment should be made when the beans are about 5 inches high. At this time most if not all of the overwintering beetles will be on the plants and some eggs will have been deposited. A second treatment may need to be applied a week or ten days later by which time most or all of the eggs will have hatched.

For the first treatment, parathion or TEPP is preferable because either is more effective against the beetle stage.

For the second treatment, the rotenone and DDT combination or the parathion and DDT combination is advised. Rotenone alone can also be used effectively against the bean beetle but it is not fully effective against the grown beetles unless heavier than usual applications are made; moreover, it does not control leafhoppers.

In a survey made in 17 dry-bean-growing counties 67.4 per cent, or 97,825 acres, of the dry bean crop of the State was treated either once or twice for bean-beetle control in 1950. The proportionate insecticide used were: ¾ per cent rotenone plus 2 per cent DDT combination as a dust, 57 per cent; parathion as a spray or dust, 26 per cent; rotenone used mostly as a dust, 13 per cent; 1 per cent parathion plus 2 per cent DDT combination used mostly as a dust, 4 per cent. The average estimated control was 68.7 per cent.

In 1949 and 1950, the bean beetle was present in very destructive numbers, especially on the most commonly grown Red Kidney variety. This heavy infestation probably resulted from the two somewhat previous mild winters. Prior to that time the beetle infestation was such that in most of the bean-growing area the need for control appeared doubtful, especially to growers who were unequipped.

It appears that when an average of one beetle is found on 10 feet of a row of bean plants when they have from two to four leaves, control is profitable. The cost is $5

or less per acre for one treatment, and such a number of beetles can readily reduce the yield per acre by 1 bushel or more of beans. On July 4 and 5 in 1950 a survey made in 29 fields in five counties showed an average of 2 beetles and 1.8 egg clusters (about 25 eggs per cluster) to each 3 feet of bean-row plants. This degree of infestation would have resulted in almost total loss of the crop if control had not been practised. There are strong indications that all growers of dry beans, and especially those who grow the Red Kidney variety, must be prepared to combat the beetle in most if not all years. Better timing of the treatments and more thorough applications by directing nozzles to the plants and rows would have increased the degree of control appreciably at no increase in cost.

LOW-GALLONAGE SPRAYS

A highly efficient and moderate cost low-pressure and low-gallonage per acre sprayer has been developed by Dr. G. E. R. Hervey of the New York State Agricultural Experiment Station at Geneva. It is mounted on the rear of a tractor with the nozzle boom in front. It has given excellent control of the bean beetle on dry beans when two treatments are applied (July 13 and 20 in 1950). One half pint of 25 per cent parathion emulsion, applied twice to an acre of beans in 10 or 20 gallons of water at 80 pounds pressure when the plants were 5 to 10 inches high, gave almost perfect control of the beetles or of their larval stages. Two fan-type or T-jet nozzles were used for each row; the nozzles were directed somewhat toward the lower surface of the leaves from a drop pipe. Cone-type nozzles were not so satisfactory as those of the T-jet type. Four rows are treated at a time. At a forward tractor speed of about 5 miles an hour, an acre of beans can be sprayed with a small gallonage and in relatively short time.

A 20 per cent TEPP emulsion used at the rate of 1 pint in 20 gallons of water has also been effective when applied in a low-pressure type of sprayer. Thorough coverage of the lower surface of the leaves always increases the efficiency of the sprays.

Details for the home construction of such a sprayer may be obtained from the county agricultural agent or from the experiment station at Geneva, New York.

INSECT CONTROL ON PICKING OR CANNERY SNAP BEANS

The seed corn maggot is likely to reduce the germination of snap beans when the seed is planted prior to the maggot-free period in up-state New York which is about June 15. Such early plantings should be made with seed coated with an insecticide and a fungicide.

Flea beetles are sometimes destructive to the very young plants. They can be controlled with rotenone, DDT, or parathion as described on page 25.

Snap beans, because they mature over a shorter period of time, are not likely to be severely attacked by the bean beetle. This is especially true if growers will plow under all vines immediately after harvesting a planting. Such a practice results in the death of many larvae by starvation, thus helping to slow this pest in building up to destructive numbers.

When the bean beetle needs to be controlled on picking or cannery beans, the treatments are made best against the grown beetles. At this time parathion can be used as described under beetle control on dry beans. It should not be used within fifteen days of harvest. The non-poisonous insecticide rotenone may also be used as a spray or a dust in combination with DDT as described under beetle control on the dry bean crop. However, no DDT should be used within 30 days of harvest.

There are times when leafhoppers are present on cannery and picking beans and bean beetles are absent. When an average of two immature or adult leafhoppers per plant are present on half-grown or smaller plants, control appears to be justified. The application is a 2 or 3 per cent DDT dust, or a spray composed of 2 pounds of 50

per cent wettable powder of DDT in 100 gallons of water. A quart of a 25 per cent of the emulsifiable form of DDT could also be used in 10 to 20 gallons of water applied in a low-gallonage type of sprayer. A parathion spray or dust is also effective against leafhoppers. Methoxychlor could well be substituted for DDT.

The low-pressure low-gallonage sprayer (page 31) is also adaptable to insect control on cannery and picking snap beans.

ANTHRACNOSE

The most characteristic symptoms of anthracnose (caused by *Colletotrichum lindemuthianum*) are the black, sunken cankers on the pods. In the center of the lesions is a salmon-colored ooze. Similar lesions are found on the cotyledons of the young plants and on the stems. The most noticeable symptoms on the foliage are the blackened, dead portions of the veins on the underside of the leaf. The stems may be rotted off just as they emerge from the ground or the cotyledons may be destroyed. With either condition the plant dies or becomes worthless. Later infections harm mostly the pods and their seeds. The mature infected seeds may or may not be discolored.

The organism that causes the anthracnose is carried over winter in the bean seed and in the diseased bean refuse left in the field or in the bean straw. It does not live long in the soil without beans and is not known to attack any weed hosts or other farm crops. When affected seeds are planted, the organism is pushed aboveground on the cotyledons, and from there it is scattered by the splashing and washing of rain, by insects, and on tools and clothing to all parts of the field. It grows through the pods and affects the new seed beneath the spot.

The disease is influenced much by the weather, and is worse in rainy weather when the soil is wet, the humidity of the air is high, and the temperature is between 63° and 75° F. Water must be present before the spores are liberated.

Control

Anthracnose again is so prevalent in the State that control measures have a renewed urgency. Certain general recommendations have proved beneficial, such as plowing under in the fall all diseased refuse, practicing three- to six-year rotations with other crops, using well-drained soil, refraining from cultivating the field when the plants are wet, and keeping the field free of weeds so that the plants will have good air drainage.

The principal control measure, however, consists in procuring healthy seeds or those that are resistant to anthracnose. In gardens, healthy seeds can be procured by picking ripened pods, which are perfectly free of all spots or specks. At present nearly 90 per cent of the Red Kidney seed planted in the State and much of the snap-bean seed come from the Sacramento Valley in California or from Idaho. Certain areas in these two States are free from both anthracnose and bacterial blight.

Breeding is now being conducted on a large scale and promises to increase materially the resistant strains that already are available. The Robust, Monroe, and Michelite pea bean, the Wells Red Kidney, the Geneva, and the Improved Perry Marrow are among the varieties already in use, and others will be developed later.

Most pole beans are fairly resistant. Among the wax beans that are resistant to two of the three anthracnose strains are Coopers Wax, Florida White, Golden Cluster, and Crystal White. Resistant varieties among the green snap beans, such as the Logan, are still few in number, but there is much hope for the future in the large number of strains that are being bred. Bountiful, Tendergreen, and most Refugees are very susceptible.

In seed fields, spraying with Fermate, 2 or 3 pounds to 50 gallons of water, has shown promise in helping to grow clean seed stock.

BACTERIAL BLIGHT

Bacterial blights (caused by *Pseudomonas phaseolicola, Xanthomonas phaseoli* et al.) in some of their symptoms may be confused with anthracnose, although all mature lesions are quite distinct. At least three prominent injuries are produced on an infected plant. Large brown blotches, often bordered by a yellow or reddish halo, are the distinctive symptoms on the leaf. The whole leaf later may die, and defoliation of the plant takes place. The second symptom is caused by a girdling of the stem at one of the lower joints, so that the whole plant wilts or falls over, and is sometimes known as *tip-over*. The third pronounced symptom is the canker on the pod. This rarely is circular as in anthracnose, and never is coal black or deeply sunken. The blight causes rather indefinite, water-soaked spots, usually with reddish margins, on the pods. At times a white or yellow ooze may appear on these affected parts. The infected seed may be discolored, but most frequently it is not.

The bacterial blight is caused by any one of six bacterial species and varieties whose life histories are practically the same. The organisms live overwinter in the seed and in the bean refuse in the field or in the bean straw. Their life histories, so far as the infection of the young plants and the spread of the disease are concerned, are the same as for the anthracnose fungus. In addition, the bacteria may enter the plant at any point and pass entirely through the water ducts without causing symptoms on the outside. Thus bacterial blight is spoken of as being *systemic* in nature. For this reason it is impossible to say whether beans are free from the disease even though the pods in which they grew looked perfectly normal.

The "old-fashioned" bacterial blight, which causes the very large blotches on the foliage, comes only in seasons when the average temperature is high, and rarely assumes serious proportions. The halo blight, which causes numerous small spots, comes when temperatures are not above average and moisture is present. The halo blight is most destructive and requires constant attention.

During the past few years fuscous blight, caused by a strain of *X. phaseoli*, has become injurious, especially on Michelite, but has been found also on Marrow and other varieties. It causes a glistening yellow discoloration under the seed coat of white beans. In general, its symptoms are about midway between those of common blight and of bacterial wilt which rarely occurs in this State.

Control

The general control measures for bacterial blights are the same as those given for anthracnose (page 15). But the problem of harvesting healthy seed or the breeding of varieties resistant to bacterial blight is far more complicated than when only anthracnose is concerned. Because this disease is systemic, the bacteria may enter the seed by way of the water ducts, and furnish no sign of their presence. Therefore pod selection for the control of blight is no help. Furthermore, few resistant varieties can be used in breeding resistant strains.

As has already been shown in the discussion of anthracnose, a part of California and of Idaho are free from bacterial blight. The one objection is that the blight-free areas do not produce so much seed as is required in the East, and occasionally a carload is received that evidently came from some other source, judging from the large amount of disease found in the fields planted with this stock.

Storing seeds two years kills most of the seed-borne bacteria causing common and fuscous blights, but aging of seed does not reduce the inoculum where halo blight or wilt is concerned.

Varieties of beans as Robust Pea, Monroe, Michelite, Yellow Eye, Marrow beans, and old fashioned Refugees are resistant enough so that seed can successfully be

grown locally. Bountiful, Idaho Refugee, and U. S. No. 5 are susceptible, and as soon as possible must be replaced by resistant strains. Strains of Red Kidneys and White Kidneys are being bred at Cornell and should be available to growers within the next few years. Snap-bean varieties are now being bred and also should be on the market soon. Full Green, bred and named by the United States Department of Agriculture, has pronounced resistance to halo blight but the pods are shorter than the market usually demands.

Some pole beans, including Blue Lake and Kentucky Wonder, are resistant enough to the four types of bacterial diseases so that they can successfully be grown in the State. The common bacterial blight is rarely destructive, but occasionally can cause appreciable loss on Bountiful, Common Red, or White Kidneys, Stringless Green Pod, Black or Red Valentine, and many of the wax beans. Halo blight, which is the most destructive of the bean diseases, attacks most severely Plentiful, Bountiful, Streamliner, Low's Champion, and Common Red Kidney. The fuscous blight in recent years has proved injurious to Bountiful, Common Red or White Kidney, Perry Marrow, Michelite, and Tendergreen.

Neither spraying nor seed treatment is effective in combating the bacterial blight.

Care should be taken not to wet the seed for inoculation with legume bacteria; if only a few infected seeds are present, the wetting may spread the blight bacteria to all the other seeds.

MOSAIC

The bean leaves affected with mosaic (caused by a virus) have irregular light-yellow areas merging with dark-green patches, producing the characteristic mottling, or mosaic effect. The darker areas develop faster than do those having the yellow tinge, with the consequence that the leaf is much puckered, especially along the midrib, and the edges are cupped downward. The affected plant may have a sickly yellow color; nevertheless it remains alive until the end of the season. Early infected plants rarely bear any seed even though they may continue to blossom until autumn.

Mosaic is caused by a virus that overwinters in the bean seed, and probably occasionally in living white-sweet-clover roots. The virus is carried from one plant to another by sucking insects, by rubbing one leaf against another, and in any other manner that sap from one plant may be transferred to the other.

Infection is favored by high temperature and high humidity at the time of inoculation.

The clover mosaic (yellow mosaic) also may attack beans. This mosaic is not carried in the bean seed, but lives over winter in several of the perennial legumes.

Control

Among the field beans, the old type of pea variety was so susceptible to mosaic that its growing became a complete failure. It was replaced by the Robust pea, which is immune or nearly so to the older strain of the virus. But it and Michelite are susceptible to Burkholder strain 15 of the virus that recently was discovered. Breeding developed a strain of Michelite that is resistant to these virus strains and has been named Monroe. The only other field bean that is much affected is the Medium. Since no resistant strains of this are available, some other variety must be employed in its place if the seed stock has become generally infected. All other field beans can be grown without much danger of loss from mosiac.

Among the snap beans the Refugee types are the most likely to be affected. Therefore, the Idaho Resistant Refugee, the U. S. No. 5, and Sensation have been developed for the canner. Unfortunately, they are susceptible to bacterial blight. The common market gardening beans are mostly fairly resistant, and under ordinary conditions can be grown without fear of any pronounced reduction in yield. The

United States Department of Agriculture has bred and named four green-podded varieties resistant to the common mosaic: Contender, Top Crop, Rival, and Full Green. The first resembles Black Valentine, and the others, Tendergreen. Ashley's Wax is immune to both the common mosaic strain and to Burkholder strain 15. Scotia is very susceptible to both strains.

Seed treatment and spraying or dusting are of no value in the control of mosaic. It has been suggested that if seed is kept for several years, the virus will die and a healthy crop can be grown from this seed. This idea is erroneous, for the virus will remain active as long as the seed is alive.

If the yellow mosaic becomes troublesome, beans should not be grown immediately adjoining fields of clover, sweet clover, or gladiolus. Blue Lake, Refugees, and Red Kidney are very susceptible to this mosaic. The virus is not seed-borne.

Lima bean mosaic is caused by a strain of the common cucumber mosaic virus. It attacks also cucumber, Turkish tobacco, zinnia, tomato, pokeberry, eggplant, peppers, petunia, horse beans or Fabas, and cowpeas. The disease is more likely to be prevalent on the small Sieva type of limas than on the large Fordhook types. Among the resistant ones are Fordhook, Challenger, Burpee Best, Carpinteria, Large White, and Leviathan. When Fordhook and Sieva were crossed, one of the resulting hybrids, U. S. 343, was susceptible, and the other, U. S. 243, was resistant.

The virus is not carried in the bean seed, but is transmitted by aphids from overwintering hosts. The destruction of weed or flower hosts or the growing of resistant varieties is recommended.

DRY ROOT-ROT

The root-rot (caused by *Fusarium* spp.) affects directly only the roots of the plants; but the parts aboveground are stunted, may turn yellow and wilt, and usually die before the plants mature. If infection is only moderate and rather general, the plants remain alive until harvest, but the whole field will have the appearance of being undernourished. The plants may be affected as soon as they emerge from the ground; usually, however, the trouble is more common on the older plants. When these are pulled up, the side roots are found to be rotted away, and the taproot has turned brick red and is hollow and dry. New side roots may be forming on the stem above the lesion.

The root-rot is caused by a fungus that lives in bean refuse and also in the soil for several years. It grows into the roots and up through the water ducts thereby causing the plant to wilt. The fungus rarely fruits until the affected stems or roots are old and have started to decompose. The spores and the mycelium are carried into the soil on tools and horses' hoofs and in bean-straw manure. They also may be splashed by rain or carried by floods. In spite of all these methods of dissemination, the fungus spreads rather slowly.

Probably the fungus affects no other crop. A Fusarium on the pea looks very much like the one on the bean, but the two are distinct so far as the hosts are concerned.

Control

When putting into practice root-rot control measures, it must be kept in mind that the pathogen is not seed-borne, but that it is strictly a soil organism. Because it is carried with the bean straw and because the heaviest soil infestation is found in the part of the State where winter lambs are fed on the straw, great care should be taken in manuring the different fields on the farm. The bean refuse should always be hauled to the part of the farm where beans probably never will be grown, or placed in the fields where beans will not be grown for six or more years.

It is not known how long the root-rot fungus can live in the soil. It has been demonstrated, however, that where a six-year or longer rotation is practiced, the

disease is held in check enough to grow profitable crops. On the other hand, it has been shown that where the usual three-year rotation is practiced, root-rot increases until finally bean growing in those fields becomes an impossibility.

Aside from the correct disposal of the bean straw and long rotations, a few general recommendations are made: Any diseased-bean refuse left on the field should be turned under deeply by fall plowing. Beans should be planted only on well-drained, well-fertilized soil that is likely to give an excellent growth of vines. Cultivation should cease as soon as root-rot once appears. If the base of the plant rots off and new side roots form above the lesion, the plant may live if the newly formed roots are not cut off by the cultivator. The more plant food available in the soil, the faster these side roots will form and the more chance there is for recovery.

Seed treatment and spraying are of no value in the control of root-rot. Yellow Eye beans, Bountiful, Kidney, Marrow, and Refugees are very susceptible and should not be planted in infested soil. Robust and Michelite pea beans, Hodson Wax, and a few other commonly grown varieties are fairly resistant, and usually can be grown successfully even in heavily inoculated soil.

POWDERY MILDEW

Powdery mildew occasionally may cause severe losses in snap-bean fields. The fungus *(Erysiphe polygoni)* produces a talcum-like, white covering over parts or all of the foliage and more rarely on petioles and young pods. When the disease progresses rapidly, the affected leaf may curl and die. Its occurrence is likely to be most severe late in the summer when the temperature is fairly high and the air is humid without many washing rains.

The fungus attacks nearly all types of beans classed under the Latin names *Phaseolus* and *Vigna* (cowpea). The strains on clover, sweet clover, alfalfa, and other legumes do not infect beans. On beans themselves here are strains of the mildew fungus, so some varieties of snap beans are resistant to one or more of these strains and susceptible to the remainder. Among those that have been listed as fairly to highly susceptible are: Bountiful, Plentiful, Streamliner, Common Red Kidney, Robust, most Refugee types, and Refugee Wax. The more resistant ones usually are: Florida Belle, Horticultural and French Cranberry, Kentucky Wonder, U. S. No. 5 Refugee, Stringless Green Pod, Black Valentine, Florida White Wax, Hodson Wax, Brittle Wax, and Sure Crop Wax. Most other varieties appear intermediate in susceptibility.

Control

It is probable that crop rotation is helpful and is recommended. It may be possible to select varieties that are fairly resistant in a given locality and can be grown without any fungicide protection.

In California a blue vitriol (copper sulfate) spray of about 5 ounces dissolved in 100 gallons of water without lime is suggested. A spreader is imperative when applying this solution. In practice on farms it did not prove so effective as did sulfur dust. Under New York conditions, pure sulfur is very injurious to beans and cucurbits. Therefore, it is recommended that as soon as mildew begins to appear in the field, the crop be dusted with 20 or 25 pounds of sulfur mixed in 80 or 75 pounds of a 6 per cent low-soluble copper dust. One application may be sufficient, or if the disease is not checked enough, a second application may be advisable from seven to ten days later.

Mildex (also known as Iscothan and Karathane) has proved especially effective against powdery mildews on several crops, and should be tried on beans where powdery mildew has been a problem. Four ounces in 100 gallons have been recommended, beginning after mildew appears and repeated once a week later.

DOWNY-MILDEW OF LIMA BEANS

The most conspicuous symptom of downy-mildew (caused by *Phytophthora phaseoli*) is the white downy mold in patches or completely covering the bean pod. The fungus grows through the pod wall into the bean. The whole structure finally shrivels, dries, and becomes black. Such black dried pods are common in badly infested fields. The fungus attacks also the young shoots, the flowers, and the leaves. The tender branches and the flower-pedicels are distorted in shape and covered with the mold. The white mycelial weft appears very sparingly on the leaf, but the veins may be purplish in color, twisted, or otherwise distorted.

The time of incubation of the fungus is so short, the amount of inoculum so abundant, and the means for dissemination so nearly perfect, that within a few days it can sweep over a planting and leave nothing but blasted pods. Much of the early infection comes from the diseased seed. Within a few days, fruiting bodies are formed on the surface of the pod, the stems, or the leaves, and the life history is repeated. Bees or insects collecting nectar carry the conidia from diseased to healthy blossoms. The wind, too, is an important factor in dissemination, as are flowing water and the splashing of rain.

Cool weather and moisture are favorable for the development of the downy-mildew, as is attested by the fact that in a rainy season the fungus grows even after the first fall frosts. It is most abundant in the districts where the night temperatures are low and the midday temperatures are relatively high. It attacks Fordhook types much more readily than it does Henderson Bush. Breeding for suitable resistant strains is under way at several agricultural experiment stations.

Control

Long rotations, destruction of the diseased vines in the autumn, and the selection of seed beans from a healthy crop, are three important steps in controlling bacterial spot, Diaporthe pod and leaf spot, and downy mildew of lima beans. Far-western-grown seed is recommended. As a supplement to the above-named control measures, spraying weekly with bordeaux mixture, 4–4–50, or dusting with a 6 per cent low-soluble copper dust is suggested. It is advisable to make as few applications of the spray or dust as control measures permit, for the fungicide may reduce the set of pods. The Henderson Bush is more susceptible to copper injury than is the Fordhook. Possibly bordeaux mixture made with lime high in magnesium (dolomitic lime) is safer to use on lima beans than that made with the more nearly pure calcium lime. If bordeaux is applied, as many pounds of lime as of copper are required, for reducing the lime increases the injury to the crop.

The insoluble or fixed coppers now available locally may be used instead of the bordeaux mixture. Four pounds in 100 gallons is the recommended strength. The Zineb or Nabam groups of fungicides, and Manzate when applied twice a week and in the strengths recommended by the manufacturers, have proved effective against the three diseases and caused less injury than does bordeaux mixture. Since the disease occurs only during certain years and its extent cannot be foretold, it is necessary to spray or dust each year. The grower must decide whether the loss of his lima beans has been frequent enough to justify his use of sprays. In New York, applications seldom need to be made before July 15. The sprays can be combined with those for the control of the bean beetle (page 12) and red spider.

BACTERIAL SPOT OF LIMA BEANS

Lima-bean leaves affected with bacterial spot (caused by *Pseudomonas syringae*) have small, reddish brown irregularly circular spots in which the tissue is thinner

than that of the normal leaf. As the dead cells become dry, the center of the spot turns gray and may crack open or fall away. On the lower leaf surface, the veins may turn red or reddish brown. More elongated spots than those on the leaves are also produced on the stems or pods.

The bacterium causing spot of lima bean is also known to cause blight of horse beans, pear, sweet cherry, sweet sorghum, flowering balsam, stocks, lilacs, cowpeas, and common beans. It probably never lives over winter in the seed and bean refuse. It spreads rapidly from lilac and wild cherry during wet weather and at a temperature of about 85° F.

Control

The crop should be sprayed or dusted as suggested for the control of downy-mildew (page 20). The bean fields should not be near lilac hedges, and all kinds of wild cherries should be eradicated.

POD SPOT AND LEAF-BLIGHT OF LIMA BEANS

The pod spot (caused by *Diaporthe phaseolorum*) is confined mostly to lima beans and is more destructive on the pole limas than on the bush varieties. It has been reported also on pepper plants. There is a similar disease on soybeans, but the fungi on the two crops are different. The pod spot seldom is found in upstate New York because of the cooler climate, but may occur on Long Island when the summer temperatures and rainfall are higher than usual.

Large, brown patches are produced on the leaves. Young pods rarely are infected. On the older pods, brown dead areas may be formed with many minute black pimples, or the black pimples may be present without any special tissue discoloration. These same black bodies are also on the leaf spots and are the fruiting bodies of the pathogen.

The fungus lives on and in the seed and in the old refuse in the soil. It apparently is able to remain alive in the soil for two or three years. It is disseminated with the seed, and in the field with the splashing rain or washing dirt.

Control

Since the disease has been found mainly in the States bordering on the Atlantic Ocean, seed should not be obtained from this area. Far-western-grown seed should be free from infection, and therefore is recommended. At least a four-year rotation is desirable. In addition, spraying or dusting as suggested for the control of downy mildew will keep the fungus from multiplying (page 20). The sprays or dusts should be applied before there is danger of widespread infection.

CABBAGE, CAULIFLOWER, AND RELATED CROPS

THE MOST serious insects and diseases with which the grower of these crops must contend are root-maggots, black-rot, blackleg, aphids, worms, and thrips. Seed treatments, insecticides in setting water, in the fertilizer, or on the soil surface around plants, and dusts or sprays on the growing plants are necessary to control these pests.

CABBAGE ROOT-MAGGOT

Plants raised in an outdoor plant bed or those newly set in the field in May are likely to be severely injured and often killed as maggots feed upon their roots. The maggots are the larval stage of a fly (*Hylemyia brassicae* Bouché). Cauliflower, sprouts, radishes, and turnips are more susceptible to attack than is cabbage, but

all need protection, especially in spring. Late-planted crops of cabbage and cauliflower usually escape serious injury in the field.

The flies are readily seen on the plants in early spring when the first plants are set in the field. This is about May 10 in up-state New York in an average season and a week or ten days earlier on Long Island. The fly resembles a house fly in size but is more grayish in color. Its eggs are tiny, cylindrical, and white, and have delicate markings evident with the aid of a magnifying glass. They are placed on the stems of plants or in soil cracks near the plants. It is important for a grower to be able to recognize the eggs because he may want to apply one of the soil-surface control treatments which must be made by the time the first eggs are laid, or certainly before any of the eggs hatch.

From three to eight days are required for the eggs to hatch their tiny white maggots. These rasp the surface of the stem of the plants as they move gradually to the roots. As the maggots increase in size, a group of from ten to twenty feeding on the roots of a plant cause it to acquire a bluish cast in place of its normal green. On hot days during the first half of June in up-state New York, and especially if the soil is somewhat dry, the older leaves turn yellow and the plant, its roots entirely eaten, finally dies. This takes place a week earlier on Long Island and in the lower Hudson Valley. Sometimes regular irrigation overcomes a moderate maggot infestation.

Plants that have died recently from maggot injury usually show either mature maggots or brownish cocoons about $^{3}/_{16}$ inch in length, which represent the inactive, or pupal, stage of the maggot. It is from these pupae that the flies emerge to produce another brood or two of maggots late in the season.

Control

Several control methods can be used. One or more are applicable to different conditions. Among them is the inclusion of the insecticide chlordane in the fertilizer or in the setting water at transplanting. Some insecticides are newly developed and should probably be tried only on a limited scale. Applications of dusts, such as the calomel-lime mixture, chlordane, or dieldrin, if made on the soil surface around newly set plants, must be made before any eggs hatch. The county agricultural agent can usually supply information on hatching dates.

Treatment of Plants in the Plantbed

When the young plants are an inch high the soil can be dusted until it is somewhat white with either the 4 per cent calomel-limestone dust or a 5 per cent chlordane dust at the rate of 35 to 40 pounds per acre.

Another treatment is to dust either of these on the fitted plant bed at the rate of about 40 pounds per acre, and then to work it into the soil to a depth of 2 to 3 inches. Either method has given good control for many growers in the past two years. The tiny maggots coming from the eggs are killed as they try to work their way through the barrier of the insecticide to the roots of the plants.

The dusts should be applied uniformly with a knapsack or bellows type of duster. A row-crop duster is used by some growers on larger plant beds.

Maggot control in the plant bed can be also procured by applying chlordane but not calomel as a spray. It is necessary to use 2 quarts of a 42 per cent emulsion of chlordane or 1 quart of a 72 per cent strength of chlordane emulsion per acre. Either quantity may be added to whatever amount of water per acre that the sprayer being used will apply. It may be 100 gallons per acre in a high-pressure sprayer or from 25 to 50 gallons per acre in a low-pressure or weed type of sprayer. It is important to get the proper quantity of the insecticide distributed uniformly over the size of the plant bed to be treated.

Whether dust or spray form of the insecticide is applied, it is desirable to work it into the ground within 24 hours after application.

Control Treatments at Transplanting Time

In setting water

Many growers have included either chlordane or lindane in the plant-setting water in the past two years and had excellent maggot control while the plants were being set in the field. In some cases a liquid starter solution was also included.

Two liquid ounces of a 42 per cent chlordane emulsion or 2 ounces of a 20 per cent lindane emulsion are added to each 50 gallons of setting water. Thorough stirring is necessary. From ⅔ to ¾ teacupful of the insecticide-setting water mixture is then tripped in the row at the plant-setting interval. The plant is then set *exactly* where the setting water was tripped. Maggots will not be controlled if the plant is set ½ inch or more from where the water was placed.

Apparently this method of applying the insecticide does not give perfect control in spring if the treatment is made more than two weeks before the eggs are laid; nor does it give perfect control when the grower needs to use considerable irrigation water. This is probably true only in sandy or leaching types of soils. It will, however, give commercial control, with a loss of only a few per cent of the plants, in seasons when maggot injury is severe.

In fertilizer

The application of an insecticide premixed with fertilizer is not advised. Observations indicate that growers fail too often to distribute the proper amount of insecticide over an acre. They may over-fertilize and thus apply more than the required amount of insecticide.

Stem treatment

Some growers stem-treat the plants with a mixture of 1 pound of calomel and 8 ounces of cornstarch at transplanting time. This treatment is effective if carefully done. After the plants are pulled, they are placed on a board. The stems are moistened and the calomel-cornstarch mixture is shaken on them. The plants are then turned over and the stems are treated on the reverse side. The mixture flows readily through small holes made in the cap of a pint-sized jar. Some care should be taken to prevent excessive quantities of the mixture from lodging on the leaves or roots, because injury may result.

Some cauliflower growers report good maggot control when they have "painted" the stems with a 50 per cent wettable powder of chlordane, at the rate of 2 pounds in 50 gallons of water. This treatment of the stems was made at setting time. No official tests have been made with this method.

Treatment around Set Plants

In general, maggot control is best assured if the insecticide is used at the time of transplanting. Too often growers apply the soil-surface treatments tardily and after some maggot eggs have hatched. As a result some plants are lost even though a treatment has been made.

In soil-surface treatments, dusts or liquids are applied shortly after the plants are set in the field. It is wise to do this within two or three days of transplanting.

Dusts that have performed in a highly satisfactory way are: 4 per cent calomel-lime mixture (1 to 24), 5 per cent chlordane, and 1 per cent dieldrin. These dusts are applied best by a knapsack duster to drive a goodly puff to the soil and in the cracks around each plant. The amount to be used per acre varies with the number of plants but in general 6 pounds per 1000 plants are needed for adequate coverage.

It is the practice of some growers on Long Island to apply a mixture of 1 part of finely ground calomel and 10 parts of ground limestone to the base of each plant by flicking it onto the soil with a mayonnaise type of jar, in the top of which holes have been punched to re-

semble a sieve. About five holes, $^{3}/_{32}$ inch in diameter, are punched in the center of the cover and these are surrounded by about ten holes $^{1}/_{16}$ inch in diameter. The jar may be taped to a wooden handle, which eases the method of application. Here again the application is about 3 pounds of actual calomel to an acre of plants.

Substitutes for the dusts are a chlordane emulsion or a wettable powder suspension of chlordane. A 47 per cent emulsion is diluted at the rate of two-thirds of a cupful to 50 gallons of water. If a 50 per cent wettable powder of chlordane is used, it is diluted at the rate of 2 pounds to 100 gallons. The wettable powder suspension must be stirred regularly. Three-fourths of a cupful of either form of chlordane should be poured on the soil at the base of each plant. This can be done with a watering pot or from flexible outlets connected with a barrel mounted on a two-wheel cart. In general, about 30 gallons are applied to each 1000 plants, or from 350 to 400 gallons per acre.

A single treatment of either the calomel or chlordane dusts gives satisfactory control if in any future cultivation too much dirt is not thrown on top of the insecticide. It should not be covered closely with more than $^{1}/_{2}$ inch of loose soil.

Maggot Control on Radishes

Radishes are especially subject to infestation by root maggots. Planting to mature a crop prior to June 1 usually results in maggot-free radishes.

A cheesecloth screen supported by a wall of boards about 12 inches high prevents the flies from reaching the growing radishes to lay their eggs. Plants grown under cloth are likely, however, to be less hardy than those grown in the open.

Many market gardeners have controlled maggots on small red radishes by cultivating a 5 per cent chlordane dust in the seedbed to a depth of 1 to 2 inches. It was used at the rate of 40 pounds per acre. The radish seed was sown just after this soil treatment. If this method of control is tried by other growers, care must be taken not to apply more of the chlordane per acre. It must be distributed uniformly as described for the soil treatment of cabbage and cauliflower plant beds on page 22.

Maggot Control on Rutabagas

The cabbage maggot is usually harmful to rutabagas and turnips. It destroys young plants. Also, the second brood of maggots burrows into the bulb growth of these vegetables.

No field tests have been made in New York which might point to a control of the maggot on these crops. It is probable, however, that the soil treatment with chlordane as described for radishes above will give partial control. Chlordane should not be used on rutabagas and turnips after the bulbous roots are well formed. A harmful residue might be present. To determine the presence or absence of such a residue before their usage can be recommended, analyses need to be made of the grown bulbs of these crops treated two or more times with chlordane to control similar newer insects.

Killing Maggots on Growing Plants

Sometimes growers have failed to apply calomel or chlordane in time to kill the maggot eggs, or the treatments have been applied with insufficient care, and the result is an infestation of maggots on cabbage or cauliflower plants already growing in the field. Such plantings may have considerable commercial value, and the grower may wish to save them.

Limited field tests indicate that the maggots infesting the roots of growing plants can be killed with an emulsion of chlordane diluted with water and poured on the ground around the base of the plant. One quart of a 42 per cent emulsion or 1 pint of a 72 per cent emulsion of chlordane is added to 100 gallons of water. From two-thirds to 1 teacupful of either dilution is poured on the soil next to the

plant but *not on it*. The amount per plant varies with the soil type and the degree of penetration of the mixture into the soil.

Growers of cole crops should recall that once a plant is infested with maggots, it is weakened and stunted. It never develops a normal plant. It may, however, develop a saleable product. Also, plants weakened by maggots are more likely to be injured somewhat by an insecticide treatment.

Lindane and dieldrin have also been tested in the field to kill maggots infesting cauliflower plants. The results appear favorable but are inconclusive.

Parathion also kills maggots when used as a drench around the plants. One-half pint of a 25 per cent emulsion added to 100 gallons of water has given good maggot kills when from one-half to two-thirds of a teacupful of this dilution was poured on the soil around the base of each plant. When using parathion, one should follow the precautions on page 108.

STRIPED CABBAGE FLEA BEETLE

A small jumping flea beetle *(Phyllotreta vittata Fabricius)* about $^1/_{12}$ inch in length, black in color but with a wavy yellowish stripe on each wing cover, injures cabbage seedlings by eating holes in the young plants and often in the first pair of leaves. The beetles may hide in soil cracks at the base of the plants, and may even kill the seedlings before they can grow much above the soil level. Under some conditions these beetles are so numerous that they injure small plants already set in the field. The immature stage of this beetle is a somewhat cylindrical white larva that feeds on the roots of cabbage, radish, and wild mustard.

Control

Dust or spray treatments made when the beetles are present give an effective control.

DDT is especially effective but rather slow to kill the beetles. A 2 or 3 per cent

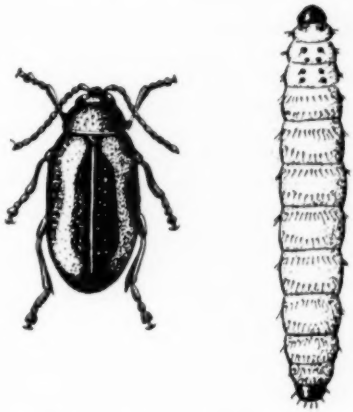


FIGURE 6. ADULT AND LARVAL STAGES OF THE STRIPED CABBAGE FLEA BEETLE

DDT is satisfactory, as is also a DDT wettable powder spray (2 pounds of a 50 per cent DDT wettable powder to 100 gallons of water), or a DDT emulsion (1 pint to 1 quart of a 25 or 30 per cent DDT emulsion to 100 gallons of water). It may be necessary to repeat the treatments to keep the growing or new leaves covered with a deposit of DDT.

A substitute for DDT is ¾ of 1 per cent rotenone dust, applied with a bellows or plunger type of duster, or shaken onto the plants through a cheesecloth bag.

CABBAGE WORMS

Green Worms

The velvety green caterpillars *(Pieris rapae* Linnaeus) that attack the leaves of cabbage, cauliflower, and related plants are the larvae of the common white butterfly seen flying about the field from early spring till late autumn. The butterfly deposits its eggs singly on the undersurface of the leaves. The eggs hatch in about a week, and the young larvae feed at first on the underside of the leaf. Later the larvae move about freely on the plant and eat out large irregular holes in the smaller leaves, and often penetrate

into the head itself. They become full-grown in from ten days to two weeks, and then transform to the chrysalis, or pupal state, in some sheltered place. The chrysalis then produces the familiar white or yellow form of the butterfly. In New York three broods develop annually.

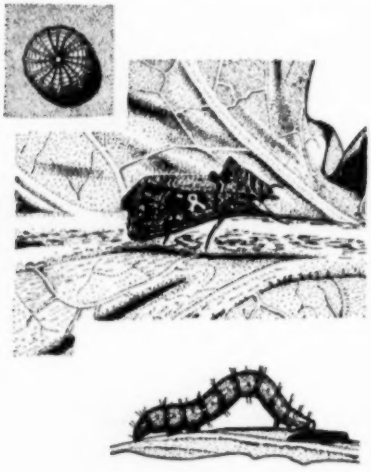
Early cabbage grown for market is seldom injured severely by this insect, although in some seasons its control by a rotenone or other insecticide is necessary just after early cabbage or cauliflower begins to head. In up-state New York, it must be watched always on late-grown cabbage beginning about July 15; from that time on it is likely to be a pest of commercial importance throughout the remainder of the season. On late-grown cabbage, which is always trimmed well before it is put on the market, stored, or used for kraut, a DDT spray or dust is often substituted for the non-poisonous insecticides such as rotenone and pyrethrum.

Cabbage Looper

The cabbage looper (*Autographa brassicae* Riley) is a pale green caterpillar marked with two dorsal stripes and a white stripe on each side of the body. It crawls about with a peculiar looping motion like a measuring worm. The looper feeds on the leaves and bores into the heads much as does the common cabbage worm, but, because it is somewhat larger and a voracious feeder, the injury it inflicts is often more severe, especially late in August and through September.

FIGURE 7. THREE STAGES OF THE CABBAGE LOOPER

Left, egg (much enlarged); *center*, moth; *right*, larva



The winter is passed in the pupal stage in the ground. Apparently the mortality of the over-wintering pupae is high, for the moths of the spring brood are rather scarce and the first brood of larvae attract little attention except occasionally in seedbeds on Long Island. There are said to be three generations a year in up-state New York.

Diamond-Back Moth

Another caterpillar that has been more than a little injurious in the past few years on cabbage, cauliflower, and related plants is the larva of the diamond-back moth (*Plutella maculipennis* Curtis). The insect hiberates in the adult stage, seeking shelter under cabbage leaves or other trash left in the field. The moths emerge in the spring and lay their eggs on the leaves. The eggs hatch in about a week, and the young larvae feed on the underside of the leaf. They eat into the leaf from beneath but do not cut holes all the way through. Later, however, the epidermis dies and falls out over these injured areas, leaving the leaf riddled with holes. When mature, the larva is about ⅜ inch in length, pale green in color, and its head is brownish yellow mottled with black. There are two or three generations annually in New York.

Cabbage Worm Resistance to Insecticides, and Substitutes for Them

There was considerable evidence on Long Island and some evidence in up-state New York late in the summer of 1952, that cabbage worms refused to be killed by

normal DDT treatments. This points to a resistance that has developed where DDT has been used regularly over the past seven or eight years. The resistance seems to be limited to certain areas in New York, but it has been reported in sections of one or two other States. It is possible that this resistance may appear in other areas of New York in the next year or two.

Increasing the dosage of DDT is not the answer to control. Other newer insecticides are known to be effective against cabbage worms but their use on cole crops has not as yet been approved by federal and state authorities.

The grower may have to return to lead arsenate, rotenone, or pyrethrum. All were used before DDT appeared.

From 8 to 10 pounds of lead arsenate per acre in a dust or spray form poisons all kinds of cabbage worms. It should not be used on cauliflower, sprouts, or broccoli after the *edible* parts of these crops have appeared. It may be used safely on cabbage after the heads have started to form. A spreader-sticker should be included with the spray.

Rotenone is effective against the green worms and the worm stage of the diamond-back moth. It does not control satisfactorily the looper. When dusting with rotenone, a 1 per cent strength should be used at the rate of 35 pounds per acre for each treatment. For spraying, a grower should use 4 pounds of a 4 or 5 per cent rotenone powder, or 1 pint of a 2 per cent rotenone extract emulsion, or ½ pint of a 5 per cent rotenone emulsion, to 100 gallons of water. A spreader-sticker is desirable when the rotenone powder is used.

Pyrethrum is necessary to kill the looper worm. Either a wettable powder or an extract emulsion may be used. It is not generally available now for use on vegetable crops. Hence it is difficult to suggest a dilution that will prove effective. In general, the manufacturer's directions should be followed.

If rotenone and pyrethrum must be used to control cabbage worms, the insects must be hit with these insecticides to be killed. This degree of coverage requires equipment that distributes the insecticides far more uniformly and thoroughly than that used to apply DDT.

Worm Control on Market-Garden Cabbage, Cauliflower, Brussels Sprouts, and Broccoli

DDT may be used on cabbage, cauliflower, brussels sprouts, and broccoli up to within 21 days of harvest. In most instances, however, worm and thrips control on the earliest grown market-garden cabbage and the rest is not necessary. A 3 or a 5 per cent DDT dust is satisfactory. Good sprays are 1 quart of 25 per cent DDT emulsion or 2 pounds of 50 per cent DDT wettable powder to each 100 gallons of water. The emulsion form may be used in a low-gallonage, low-pressure sprayer (page 30). The addition of a small quantity of a spreader-sticker may result in better performance of the insecticide. A DDT spray application should remain effective for about three weeks and a dust for somewhat less time.

If insect control is needed within 21 days of harvest, or if DDT does not appear to be effective, then rotenone and pyrethrum should be substituted for DDT as described on this page.

Worm Control on Late Cabbage

Dry Dusting

On Danish and kraut types of late-season cabbage, arsenical or DDT sprays or dusts usually are used in place of the more costly rotenone and pyrethrum sprays and dusts. They are allowable because this cabbage is trimmed well before it is marketed, thus eliminating any possibility of a dangerous residue.

About 35 pounds of 3 per cent DDT dust mixture must be applied per acre of cabbage that is heading, and more or less depending on its size. In seasons when worms are present in more than usual numbers, a series of four applications

made in upstate New York, the first about July 10 to 18, the second about August 5, the third about August 20, and a fourth about September 5, have been found profitable if a price of $5 or more a ton for cabbage is anticipated. The first treatments usually are made for the control of the green or imported cabbage worm, while the last treatment is given primarily for the control of the cabbage looper.

This last application is too often overlooked by growers, and instances are known where injury by the looper worms as they feed in the base of the heads was so severe that cabbage could not be stored safely in anticipation of a rising market price. The looper worms are difficult to reach with a poison when the cabbage heads are well developed. They are always more likely to be killed by a poison dust or spray when it is applied before the head is fully formed and when the loopers are only half grown. The applications made about August 5 and August 20, therefore, are always important for good worm control.

The quantity of dust (35 pounds) advised per acre for each treatment can be reduced somewhat if a canvas trailer about 10 feet long is attached to the row crop or power duster.

When there are small infestations of aphids along with the worms, a 1 per cent parathion dust may be included in the DDT. Often, such a dust combination may be bought ready mixed.

Wet Sprays

Effective DDT sprays for worms and loopers are prepared by mixing 2 pounds of 50 per cent wettable powder of DDT, or 1 quart of the 25 per cent emulsifiable form of DDT, in 100 gallons of water. These sprays applied at the rate of about 125 gallons per acre and with some regularity also afford good control of thrips. The emulsion spray of DDT also gives some aphid control; but for a developing or severe infestation of aphids, 1 pound of 15 per cent wettable powder of parathion should be added to the 100 gallons of DDT spray. Substitutes for this aphid spray are listed under cabbage-aphid control (page 29). Three or four sprays applied between July 15 and September 5 under up-state conditions are usually necessary to control all worms, aphids, and thrips.

Insecticide Hazards

There is some danger in feeding the remnants of cabbage treated with DDT to livestock that is being milked or to steers being readied for market. An application of DDT should not be made within 21 days, nor an application of parathion within 15 days, of feeding such stalk and leaf remnants. The hazards of insecticide residues can often be obviated by early treatments; that is, when the insects first appear.

CABBAGE APHID

The cabbage aphid (*Aphis brassicae* Linnaeus) usually is most abundant and destructive in seasons of drought when its feeding, combined with unfavorable cabbage-growing conditions, often stunts or even ruins a crop within three weeks. Observations indicate that growers too often neglect to control this insect, or that they postpone treatments until after commercial injury is evident. While it is true that rainy weather is likely to bring about an outbreak of disease among the aphids and thus wipe them out within a few days, it also is true that commercial injury which could be prevented by early treatments begins to develop when the aphids are present only on plants here and there in the field. It is at such a time that spot-dusting or spraying to prevent or slow up the spread of the aphids is always commercially profitable. Too often growers wait until the feeding of a colony of aphids has curled the leaves or they have moved to the heart of the plant, and it is then next to impossible to reach them with a necessary contact type of spray.

Photograph from G. E. R. Hervey

FIGURE 8. APHIS INFESTATION ON CABBAGE

Control

On Seedlings

It has been observed that aphid infestations in a field often are a result of transplanting seedlings that are inconspicuously infested with lice. This is particularly true of southern-grown plants. Small aphid infestations also develop at times in the plant beds.

It is a good general practice to dust cabbage transplants with a 4-per-cent-nicotine–lime dust just prior to setting the plants. As a substitute they can be dipped at transplanting time into a solution prepared by mixing 2 ounces of nicotine sulfate and ½ pound of soap in 10 gallons of water. Probably roots should not be immersed in the spray, although some growers make a practice of dipping entire plants without evident injury.

In the Field

With dusts

Highly satisfactory insecticides for the control of aphids are now available. In dusts these include a 1 per cent parathion or a 1 per cent TEPP freshly prepared, or a 5 per cent Malathon. A 4-per-cent-nicotine–lime dust or a 3 per cent fixed-nicotine dust are also effective when temperatures are fairly high and if applied when there is little breeze. About 35 pounds of a dust is needed to an acre. Nozzles should be directed so that the dusts will envelop the plants. Malathon is used at the rate of 1 quart of the 50 per cent emulsion to 100 gallons of water. It is somewhat safer to the person doing the spraying than parathion or TEPP.

With sprays

Sprays may be substituted for dusts. These include 1 pound of 15 per cent wettable powder of parathion, or from ½ to 1 pint of 25 or 15 per cent parathion emulsion or one quart of 50 per cent emulsion of malathon to 100 gallons of water. Other organic phosphate compounds that have been used successfully by growers in 1950 are TEPP and Metacide. These should be used at the manufacturer's directions. A nicotine-sulfate spray is also somewhat effective under the best of spraying conditions.

The sprays can be applied with a brush type of boom, but the nozzle arrangement and the speed of the sprayer should be such as to apply from 115 to 125 gallons per acre at each application.

Photograph by G. E. R. Hervey

FIGURE 9. LOW-PRESSURE LOW-GALLONAGE SPRAYER MOUNTED ON A TRACTOR, SHOWING FOUR-ROW BOOM AND THREE NOZZLES PER ROW

Early applications of either sprays or dusts are advisable for the best of control even with these organic-phosphate compounds. Once the aphids establish themselves under the tight leaves of a formed head, or within the folds of developing sprouts, adequate control is difficult. Early and ten-day treatments are essential to control the aphids on such crops as brussels sprouts and cauliflower and especially when such products are to be frozen or otherwise processed without any evidence of aphids in the finished product.

THRIPS

Thrips (*Thrips tabaci* Lindeman) are minute, almost invisible, insects that feed upon the lower surface of the outer leaves of cabbage and similar crops. Their feeding often causes the leaves to dry prematurely, especially in a dry period, and this results in a less vigorous plant.

Control

It has been observed repeatedly that the use of DDT to control cabbage worms results in good thrips control as well. This is an additional reason for the use of DDT on late-grown cabbage and such plants up to the time it will not be a residue hazard.

INSECTICIDE HAZARDS

Parathion and similar organic-phosphate compounds are highly toxic to individuals using these insecticides. They can affect the user if he inhales much of a spray or dust or if any of the powder or liquid concentrate comes in contact with the skin. The precautions given on package labels by the manufacturer should be followed closely for complete safety. Further details on the use of organic phosphate compounds are given on page 107.

Parathion should not be used on brussels sprouts, cauliflower, or broccoli within 10 days of harvest. TEPP presents little or no residual problems and can be used closer to harvest time.

DDT and its related compounds should not be used on sprouts, cauliflower, or broccoli within 21 days of harvest because

its residue is considered harmful to man and animals consuming it. Further details are given on page 105.

LOW-GALLONAGE SPRAYS

Field tests conducted by Dr. G. E. R. Hervey of the Geneva Experiment Station in 1949 and 1950 with low-pressure and low-gallonage sprays have shown that this type of sprayer is highly adaptable to efficient cabbage-insect control. The investment in such a sprayer is a moderate one. It operates at 80 pounds pressure and distributes the recommended quantity of an insecticide in 20 gallons of water per acre rather than in 100 gallons applied by the high-pressure sprayer. Details for the construction of such a sprayer to be mounted on a tractor can be procured from the New York State Agricultural Experiment Station at Geneva, New York, or from the county agricultural agent.

BLACK-ROT, OR BLIGHT

Black-rot or blight (caused by *Xanthomonas campestris)* attacks many cruciferous plants, including cabbage, cauliflower, kohl-rabi, brussels sprouts, turnips, broccoli, and rutabaga. The bacteria live on and in the seed or in the cabbage refuse in the soil. They may live from one season to the next also in seedbed soil, especially in coldframes and hotbeds. They may be spread by the blowing of the leaves, by rain water, and possibly by insects. After gaining entrance into the seedling, they cause a yellowing or browning of the foliage, which shrivels and dies. Young plants may be killed outright, but in older plants the organism merely blackens and kills the veins through which it advances. On cauliflower leaves it may produce numerous minute brown specks, resembling peppery leaf spot. It produces also a typical black ring in the stem. The heads may be dwarfed or one-sided, and later may decay, falling off in a slimy heap. For this reason it sometimes is named *stump-rot.*

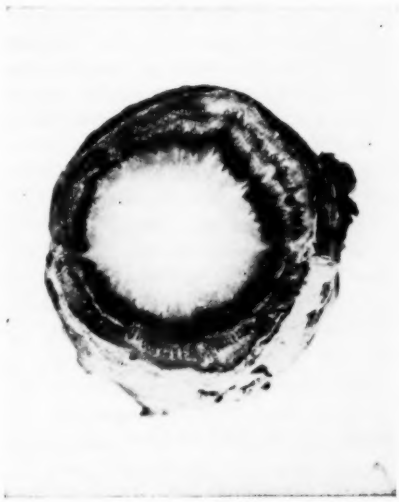


FIGURE 10. A DARK RING IN CABBAGE STEM CAUSED BY BLACK-ROT

Control

Too much emphasis cannot be laid upon having disease-free soil for the seedbed and in avoiding contaminated manure and diseased cabbage refuse both in the seedbed and in the field. Cabbage insects should be controlled and a three- or four-year crop rotation practiced. The grower should bear in mind that rape, kale, and mustard are susceptible hosts. Furthermore, the affected leaves of the year before may blow from 40 to 80 rods into neighboring fields and serve as a source of inoculum to infect the new crop. All other recommendations are worthless, however, if seed from disease-free crops is not obtained or hot-water seed treatment is not practiced (page 33).

If there is any chance that the seedbed is infested, the soil should be sterilized with steam or other heat, chloropicrin, or formaldehyde. The plants should be grown in flats that are newly filled with soil composted two to four years so that sterilization is not required.

BLACK-LEG

Black-leg (caused by *Phoma lingam*) used to result in almost the complete loss of the cabbage crop, but suitable control measures have now almost eliminated it from the State. It affects cabbage, cauliflower, brussels sprouts, and other crucifers. The first symptom is the sunken area on the stem near the ground line. The areas extend in size and depth until the stem is girdled. Small black dots, the fruiting bodies, develop within the lesion and bear innumerable spores. These are splashed by rain or carried by insects to neighboring stems and leaves, where new infections arise. The fruiting bodies develop upon the affected leaves the same as upon the stem, so their presence in the dead areas is an excellent diagnostic sign. The organism may live for at least three seasons in the soil, and is carried on and in the seed.

When infected seed is planted, the dead seeds permit the fungus to live and fruit in the soil while the cotyledons of the viable ones push above the soil and serve as a fruiting place for the parasite. Infection also occurs at the base of the new stem from the mycelium harbored under the seed coat. Dissemination and inoculation take place rapidly. In wet weather, a few infected seeds may be the source of an epiphytotic later. A common method by which this is brought about is the practice of pulling up a large number of

FIGURE 11. DIFFERENCE IN STAND FROM SEEDLINGS FROM A HEALTHY SEEDBED (LEFT) AND FROM A SEEDBED INFESTED WITH BLACK-LEG OF CABBAGE (RIGHT)

young plants and placing them together in water. If spores are present, every seedling may become contaminated under such conditions.

The Phoma is susceptible to environmental conditions. It is said to be absent from the seed-producing sections of California. In the Puget Sound district and northward, where the rainfall from May to July is extremely light, very little of the disease is present. It was supposed to be absent from Denmark but this is now known to be erroneous. In New York State it may be rare for several seasons, then become epiphytotic in nature. The severity of the disease is in direct proportion to the amount of rainfall in the early summer. It grows well at all temperatures in which crucifers thrive.

Control

Since the fungus remains alive in the soil for three years, it is necessary to practice at least a four-year rotation. The diseased stalks and leaves should not be fed to cattle, and great care should be exercised to prevent the spread of diseased cabbage refuse to other parts of the farm. If one field is diseased and another is healthy, it is a good plan to use different sets of tools in cultivating the soil of each, for the fungus may be carried readily from one place to another on the tools. No seedlings should be transplanted from a seedbed which shows even the slightest infection. The seedbed should be on soil that has never grown cabbage nor related crops, even if this requires the renting of soil in another county. Only treated seed should be planted.

To treat seed, a large tub or clothes boiler is partly filled with water and heated to 122° F. The small cheesecloth bags of seeds are placed in the water (cabbage and brussels sprouts seed for 25 minutes, all other crucifers, 20 minutes). Radish seeds are not treated. The water is stirred constantly and the temperature determined with a thermometer. As soon as the temperature begins to lower, a small amount of boiling water is added slowly so the temperature is kept constant. At the end of the treatment, the bags are removed and the seed immediately spread out to dry. This treatment may reduce germination, especially if the seed is more than one year old. The growers who live in counties where the farm bureau furnishes the hot-water-treatment service should surely take advantage of this opportunity to free their cabbage seed of black-leg. The treatment is beneficial to the crop even when the black-leg and black-rot are not present on the seed.

YELLOWS

Yellows (caused by *Fusarium conglutinans)* attacks cabbage most severly, but occasionally it may affect also Chinese cabbage, turnip, collards, kohlrabi, and kale. It is seldom present on cauliflower, broccoli, and brussels sprouts. The fungus lives in the soil and, once established, it remains there indefinitely as a potential parasite of these crops. It enters the plant through the roots, spreads upward through the vascular tissue and causes the plants to have a sickly, yellow, dwarfed appearance. Frequently the edges of the leaves change to a lavender or purplish color, and the base of the leaf turns brown. Usually the lower leaves drop one by one, beginning at the lower part of the stem. If the head has formed already, it will be left bare at the top of a naked stalk.

A cross section of the cabbage stem affected with yellows shows discolored vascular bundles similar to those found in plants affected with black-rot. In fact, a microscopic examination must be made to distinguish definitely between the yellows and black-rot diseases.

An abundant supply of potash reduces the severity of the disease somewhat. The fungus grows best at high soil temperatures, the optimum being about 82° F. Some varieties of cabbage, bred for resistance, retain that quality even at high

temperature. They are considered to have A type of resistance, others resistant only at relatively low temperatures have B type of resistance.

Control

The only effective control measure is the use of yellows-resistant cabbage varieties. Several strains have been developed from the commonly used, older varieties. The grower should select the resistant strain that best suits his market.

Some of the resistant strains with the type of resistance and their approximate number of days for maturity are: Wisconsin Golden Acre, A, 60; Jersey Queen, A, 67; Resistant Detroit, A, 67; Racine Market, A, 80; Resistant Glory, A, 80; Marion Market, A, 85; All Head Select, A + B, 85; Globe, A, 88; Wisconsin Ballhead, A, 91; Improved Wisconsin All Seasons, A + B, 92; Improved Wisconsin Ballhead, A, 97; Red Hollander, A + B, 113; Wisconsin Hollander, B, 113; Resistant Flat Dutch, A + B, 116; Bugner, A, 120. Most seed companies in this country handle these resistant strains.

Moss Curled Dwarf kale is most susceptible to yellows, Thousand-headed kale has medium susceptibility, and Siberian kale is resistant.

CLUBROOT

Plants affected with clubroot (caused by *Plasmodiophora brassicae)* have yellowish, sickly leaves or green leaves that wilt on hot days. Young plants may die outright and older ones may fail to produce marketable heads. Roots of such plants are much enlarged and malformed. These malformations vary in size from very small swellings on smaller roots and rootlets to large clubbed masses that later decay and give off bad odors.

Nearly all cultivated crops that belong to the mustard family are susceptible. The common mustard so widespread in the State is extremely so, but fortunately winter cress is immune.

The disease is caused by a parasitic slime mold that gains entrance through root hairs and injured roots. After the swelling of the roots is produced, the body

FIGURE 12. CLUBROOT AS IT APPEARS ON THE SEEDLINGS IN THE SEEDBED

of the slime mold is transformed into a mass of spores which are released into the soil upon the decay of the host-tissue. The spores are disseminated by any means in which infested soil or soil water may be carried, and with contaminated manure. They are never carried on or in the seed. The organism is reported to be able to live in the soil for a period of at least seven years and to attack susceptible plants at any time during this period. It has been stated that spores retain their viability during passage through digestive tracts of animals, but this seems doubtful. Wet and acid soils are favorable for the propagation of the parasite.

Control

The eradication of weeds that belong to the mustard family, the choice of well-drained soil, the elimination of all seedbeds that show clubroot, and the practice of long crop rotations are sound recommendations of long standing.

The first real step in control is the location of the seedbed in an area where no diseased cabbage has been grown, where no contaminated manure has been applied, and where no infested soil can be washed. It has been found that the application of lime to the seedbed merely hides the presence of the disease and does not protect the plants when they are removed from the infected soil and set into an acid soil in the field.

All beds that may have had a chance of becoming contaminated should be disinfested or treated with corrosive sublimate as suggested for damping-off control (page 100).

In the field, enough hydrated lime, or quicklime if preferred, is scattered on the plowed soil and harrowed in to produce an alkalinity above neutral (pH 7.2). The county agricultural agent or the soils specialist by making tests can determine the amount to apply to any given field.

The points in the scale of alkalinity where infection is still abundant and where control is absolute are so close together that it is possible to apply almost enough lime and seemingly get no benefits from it. Therefore, it is important that each grower have a test made of his soil, and then add enough lime to make sure that the soil reaction will be above the neutral point. No matter how alkaline the soil is, at least 1000 pounds must be applied to be effective.

Table 1. Approximate amount of lime an acre needed to control clubroot

pH of soil	Lime needed
5.0	2.5 tons
5.5	2.0 tons
6.0	1.5 tons
6.5	1.0 tons
7.0	1,500 pounds
7.5	1,000 pounds
8.0	None

The type of lime used is important. It has been proved by experiments that only quicklime or hydrated lime can be used successfully in the control of clubroot. Consequently, ground limestone and air-slaked lime are not recommended. For the same reason spring rather than fall applications are advised. If hydrated lime is applied long before the crop is planted, the lime changes to the carbonate form which is ineffective in controlling the disease. The percentage of calcium in the hydrated lime is not important as long as it is not air-slaked. In other words, if lime with a high percentage of magnesium can be bought more cheaply, it can be used satisfactorily for the control of club root. In light sandy soil or in muck soil, lime may not control clubroot satisfactorily. The muck is too difficult to make alkaline, and the sandy soil may become so dry that the lime air-slakes too quickly to be effective. Under those conditions some fungicide must be applied.

Calomel (8 ounces in 50 gallons of water) applied in the setting water is simple to use and often cheaper than lime. Cabbage requires 400 gallons or more of the suspension, while cauliflower requires as many as 700 gallons an acre. The calomel

should be bought already mixed with gum arabic or moistened with a concentrated solution of the gum arabic, before mixing with the water, so the heavy chemical does not settle too rapidly. A few plants can be protected by pouring ½ pint in a large dibble hole for each plant.

Among the crucifers commonly found in New York and tested for clubroot susceptibility are the following classes: **Most susceptible:** cabbage, brussels sprouts, some varieties of turnips, charlock, white mustard, leaf mustard, worm-seed mustard, and some species of candytuft; **medium susceptible:** kohlrabi, kale, cauliflower, some varieties of turnips and radishes, and some species of candytuft; **mildly susceptible:** rape, black mustard, some turnip and radish varieties, sea-kale, and tumble-mustard; **very resistant or occasionally immune:** winter-cress or yellow rocket, shepherd's purse, wall flower, dames violet, pepper grass, garden cress, stock, and some radishes.

In Europe a number of turnip varieties are listed as resistant or almost immune. Breeding and selection of resistant turnips are being done also in Canada and Wisconsin.

DOWNY-MILDEW OF RADISH AND CABBAGE

A downy-mildew (caused by *Peronospora parasitica*) occurs on nearly every species of cultivated and weed plant that belongs to the mustard family. Fortunately for the grower, each crop has a distinct strain of the fungus, so the one on cabbage, cauliflower, or any other related crop will not attack radish.

The disease appears as a slight yellowing on the upper side of the leaf. In moist weather a white mildew appears on the corresponding lower sides. The spot enlarges until the leaf dies. In severe cases the whole radish plant or cabbage seedling may be blackened. On older cabbage plants usually only the outer leaves are affected.

The fungus reproduces very rapidly, and enters the plant quickly. It overwinters in the soil as fungous threads and as oospores, and probably also is carried in the seed. It is not known how long the organism can live in the soil without a host crop.

All downy-mildew fungi are sensitive to weather conditions. The spores will not germinate unless the air is saturated with water and the temperature is fairly low. The higher temperatures of the day enable the germ tube to enter the radish leaf. Conditions for the development of the fungus are almost ideal in a cold frame that is not properly managed.

Control

The cold frame should run as suggested for the control of damping-off (page 100). In addition, if mildew has been prevalent in the hotbed or coldframe, the plants should be sprayed three times a week with wettable Spergon, 2 pounds in 100 gallons of water, or at about 5-day intervals with bordeaux mixture 2–2–50 or with one of the insoluble copper compounds, 3 pounds in 100 gallons of water. The applications are begun as soon as the true leaves appear and are continued until the danger of mildew infection is past. The copper must not be too concentrated because it injures crucifers.

Where manure is used generously in the bed, enough superphosphate should be added to reduce the effects of the potash on mildew production. If there is a probability that the field of cabbage, cauliflower, or turnips will have too much mildew, a fertilizer high in superphosphate and relatively low in potash, such as a 4–12–4 or similar formula, will reduce the amount of the disease. For cabbage and cauliflower, the seed should be treated as suggested for black-leg (page 33).

WHIP-TAIL, MALNUTRITION, AND TIPBURN

During certain seasons, much whip-tail on cauliflower plants and tipburn on Danish Ballhead cabbage are observed; in some fields these diseases occur almost

every year. Both are caused by unfavorable environmental conditions.

Whip-tail on cauliflower manifests itself in making the leaves more narrow than normal. The injured leaves have a "quilted" appearance, are thicker than the healthy ones, and so brittle as to be crushed easily between the fingers. The seriousness of the injury to the plant may vary from the production of a full-sized head to the entire absence of one.

In tipburn of cabbage, the tips of the leaves show brown or black margins. When the trouble is slight, only the margins of the outer, older leaves are affected; in a greater manifestation the outer leaves may be entirely dead, and the margins of the younger ones distinctly tipburned. In the more pronounced cases the whole plant is somewhat dwarfed and the head is not firm.

Another malnutrition injury on both cabbage and cauliflower is the yellowing between the veins beginning with the lowest leaves. On cabbage these leaves may drop and leave a bare head that resembles the symptoms of yellows or black-rot. Such injury has been attributed to lack of magnesium.

On cauliflower, the curd may turn brown and be bitter to the taste. Often the stems of such plants show cavities in the pith, and sometimes show brown streaks extending through the pith to the curd. This browning is due to a lack of boron.

During certain seasons when cabbage is planted early, fertilized heavily, and then subjected to hot weather after the heads have become solid, it shows much blackening of the tissue adjoining the core or as black specks throughout the head, but appears perfectly normal on the surface. Such cabbage may be rejected for market or at the kraut factory.

Control

Whip-tail on cauliflower may be produced in various ways, but commonly it is the result of an acid soil. When the disease occurs, a soil test should be made at once, and, if necessary, enough lime should be applied to get a soil reaction nearly neutral. The application should be made in such a manner that the subsoil, as well as the top soil, is made alkaline. Dr. G. J. Raleigh obtained good control on acid soils by applying to the soil near the plants 2 pounds of ammonium molybdate an acre or 4 pounds broadcast.

Tipburn of cabbage is generally attributed to potash deficiency, but more often is the result of an incorrect ratio of superphosphate and potash in the fertilizer. The tipburn apparently is not influenced much by the presence or the absence of lime. Where it persists, the condition can be improved by decreasing the amount of superphosphate and increasing the amount of potash. During a dry season the previous year, a heavy application of superphosphate may have a residual effect in producing tipburn the following year.

The 5–8–7 or 5–10–10 ratio seems to be the correct one to use where tipburn is likely to be present. Only when growing Danish Ballhead is it necessary to take this precaution, as early and kraut varieties of cabbage are more resistant to the trouble. This recommendation does not suggest a change in fertilizer practices from that recommended generally by horticulturists except where tipburn is severe enough to cause injury.

If the cauliflower curd becomes brown and bitter, borax should be added to the fertilizer. From 7 to 15 pounds an acre usually are enough. Much larger quantities may cause injury.

Magnesium deficiency can be corrected by applying liberally lime containing a high percentage of magnesium.

Danish cabbage, if desired for storage, should be planted as late as good yields will permit. The strains chosen should be those that are long in maturing, so that they do not ripen too early in the fall. This, together with applications of borax, reduces or possibly eliminates the black specks in the head.

CARROTS

CARROT RUST-FLY

The most serious insect enemy of carrots in New York is the larva, or maggot, of a small shining dark-green fly *(Psila rosae Fabricius)* with yellowish head and red eyes. The larva is a slender, straw-colored maggot about 3/10 inch in length. It burrows through the roots in all directions, leaving channels that soon acquire a rusty color. Carrots, parsnips, and celery are subject to attack. The insect breeds also in wild carrots.

The rust-fly passes the winter in the puparium stage in the soil. There are two main broods of flies and a partial third brood each season. The first brood appears about May 25, the second the last week of July, and the third the last week of September. The flies deposit their eggs in crevices in the ground close around the base of the plants. The eggs hatch in about a week. The young maggots work their way down along the main root, but feed for some time on the smaller roots and usually attain considerable size before attacking the main root itself. This habit is of great importance because it makes it possible to leave late carrots in the ground for some time after the larvae of the second brood have hatched without their becoming infested.

The common practice of growing early and late carrots in the same general locality is favorable to a rapid multiplication of the rust-fly and results in a maximum injury to the late crop. The early crop supplies an abundant source of food for the larvae of the first brood, and great numbers of the second-brood flies are produced to infest the late crop.

Control

Where late carrots are grown extensively, it would pay to make no early plantings of carrots, celery, or parsnips, and to plant the main crop after June 1. Then the first brood of rust-flies would be largely destroyed for want of food plants in which to breed, with the corresponding reduction in the number of flies appearing in the second brood. Where it is not feasible to discontinue the growing of early carrots, parsnips, and celery, the alternative is to plant the main crop after June 1, when the danger of infestation by the first brood has passed, and to harvest the crop early in September before the second brood becomes destructive. By following this method, the crop yield may be reduced somewhat, but it enables the grower to produce clean carrots profitably even in districts where the rust-fly is normally destructive. When it is desired to hold the late crop of carrots in the ground as long as possible, the field should be carefully examined at least twice a week, beginning about September 1. By carefully scraping with a knife blade several carrots pulled from different parts of the field, even a slight infestation can be detected. When the first larvae are found in the carrots, harvest should commence at once.

If it seems necessary to plant carrots later than the first week in June, the crop may not be ready to harvest early enough in September to prevent injury from second-brood larvae. Then it is important to choose a field as far removed as possible from early carrots and early celery and from celery seedbeds of the current year.

Field tests conducted in 1951 and 1952 have shown that the carrot rust fly can be controlled during its first generation only and on early planted carrots by treating the seed with parathion or aldrin. Good control was procured also when dusts of either aldrin, parathion, or chlordane were blown into the furrow at the time of planting the seed. These treatments gave better stands of the carrots because the maggots could not chew into the roots when small. Unless a safe method is found to control the second brood of

maggots which would work on the carrots not harvested before about September 15, the seed treatment would not be wholly satisfactory.

It has been found also that a 5 per cent chlordane dust applied at a time when the mid-summer brood of flies is laying eggs to produce the second brood of maggots will prevent maggot injury to late maturing carrots.

These insecticidal methods of control are not yet recommended. Chemical analyses are being made at this writing to determine any possible residue hazards involved on the harvested carrots.

CARROT WEEVIL

On Long Island early crops of carrots are subject to attack by the larvae of a small dark brownish weevil *(Listronotus latiusculus* Boheman) which in some cases ruins as much as 75 per cent of the crop. The insect injures also curled-leaved parsley, hymicha, and dill. Its principal wild food plant in this area is wild carrot. Most of the damage is done by the larvae. Badly injured carrots are almost unsalable. The injury to the parsley roots induces a yellowish silky condition of the leaves, greatly reducing their market value. With hymicha the injury to the roots may be severe enough to render them unsalable.

The carrot weevil hibernates in the adult stage in the immediate vicinity of the infested field. The beetles appear in May and soon begin to deposit eggs. The female first hollows out a cavity in a leafstalk in which she deposits 3 or 4 eggs, sealing up the opening with a blackish substance. The eggs hatch in about ten days, and the young grub begins feeding on the inside of the stalk. It usually burrows downward and generally enters the root without coming to the surface, but some of the grubs, hatching in cavities at some distance from the base, leave the stem and either fall or crawl to the ground where they soon find their way into the carrot itself. Usually several larvae attack a single carrot. Feeding is usually confined to the upper and the outer part of the root. The burrows take a zig-zag course and often coalesce, producing large areas in which most of the surface tissue of the carrot has been destroyed.

The larva becomes mature in about two weeks, leaves the root, and transforms to a pupa in an earthen cell within an inch or so of the carrot in which it developed. From six to twelve days are spent in the pupal stage. The beetles of the second brood appear in July, and lay eggs for a second brood of larvae which injure the carrots during August. A partial third brood may develop but causes little injury to the late carrots and is unimportant.

Control

Although the weevils have wings, they make little use of them, and migration from field to field is very slow. For this reason, carrots can be grown free from injury even in badly infested localities by selecting, for carrots, fields not recently used for this crop or for curled-leaved parsley, hymicha, or dill. Careful attention to the proper rotation of crops seems to be an entirely satisfactory solution of the carrot-weevil problem.

Under some conditions it may be desirable to apply an insecticide to prevent further injury to a crop infested by the weevils. A dust of 5 per cent DDT or a 1 per cent parathion might be found effective. The DDT should not be applied within twenty-one days of harvesting a leafy crop. The parathion should not be applied within fifteen days of harvest.

CARROT LEAFHOPPER

The six-spotted leafhopper *(Macrosteles divisus* Uhler) that infests carrot foliage is injurious to carrots because it transmits a disease to them known as *carrot yellows*. The disease causes the growing carrots to become misshapen and is said also to affect their taste quality adversely.

The leafhopper appears to pass the

winter on grains, particularly on rye grass. It produces a generation on this crop in late spring and the adult hoppers then migrate to carrots.

Control

Tests conducted at the Geneva Experiment Station in recent years by G. E. R. Hervey and W. T. Schroeder, have shown that carrot yellows can be reduced greatly in a planting by sprays or dusts of DDT. A 5 per cent DDT dust containing preferably from 1½ to 2 per cent of lubricating oil to make it heavy gives good control. The same is true of a spray containing 4 pounds of 50 per cent wettable powder of DDT plus 2 quarts of summer oil emulsion (like orthol–K) to 100 gallons of water.

The first application is made when the leafhoppers migrate from grain to carrots. This is usually in late July or early August under up-state growing conditions. Since the leafhoppers continue to invade the fields of carrots, it seems advisable to make three DDT treatments at ten-day intervals to procure a high degree of control.

It is probable that a low-gallonage low-pressure type of sprayer could be used effectively to apply a DDT spray, if about 2 quarts of a 25 per cent DDT emulsion are substituted for the wettable powder and applied to one acre in about 25 to 40 gallons of water.

LEAF BLIGHTS

The carrot leaf blights (caused by *Alternaria, Cercospora,* and *Xanthomonas carotae)* affect the leaves and the petioles, which turn yellow and then change to brown. During severe infection, the whole top of the plant may be killed.

Control

Spraying with bordeaux mixture, 4–2–50, or dusting with a 7 per cent insoluble copper dust controls the disease. Manzate, Ziram, or Ferbam, 2 pounds to 100 gallons of water, or Orthocide 406, 4 pounds, also are satisfactory on carrots, in some instances giving better control than did the copper. The Zineb sprays give better Alternaria control than do the Ziram ones, but the yields usually are better when the latter are applied. Applications should begin in New York State when the plants are about six weeks old. The number of applications to make depends on the amount of rainfall. During periods of low rainfall a few applications are enough. In rainy seasons, applications should be made at least once each week with copper, or at five-day intervals with the others.

The dusts or sprays should be applied, in every instance, just prior to the rainy period in order to obtain best control. Dusts must be applied early in the morning when the plants are wet with dew.

STORAGE ROTS

A number of rots may affect the carrot roots under poor conditions of storage. Usually these rots (caused by various fungi and bacteria) spread rapidly in the bin if the roots are piled closely together. The carrots to be stored should be grown in three-year or longer rotations and sprayed as suggested for leaf blights, so that the roots are as free from disease as possible when they are harvested. The temperature of the storage room should be kept as near 32° F. as possible, and there should not be too much humidity in the air. The room should be free from dripping water. Instead of solid piles of roots, there should be a layer of roots, then a layer of straw, old leaves, or other filler material. Only healthy, unblemished carrots should be put in storage, and every precaution practiced not to break the skins of the roots in piling them away for the winter.

CELERY

TARNISHED PLANT-BUG

Celery is subject to serious injury caused by the punctures of an inconspicuous brownish bug (*Lygus pratensis* Linnaeus), mottled with various shades of reddish and yellowish brown, and about 1/5 inch in length. This tarnished plant-bug is shy and very active, taking flight at the slightest alarm. It feeds on a great variety of wild and cultivated plants, and is especially abundant on certain weeds, such as wild carrot and ragweed.

The tarnish plant-bug hibernates in the adult condition under trash and dead leaves in woodlots and in stone piles, stone walls, and other convenient shelter. The bugs emerge early in the spring and feed on the opening buds of many kinds of trees and shrubs. The female inserts her eggs in the green tissue of her food plants. The eggs hatch in about ten days. The nymphs are green, marked on the thorax with four black spots. In the older nymphs the thorax and the wing-pads are mottled with brown. There are five nymphal stages, the insect becoming mature and acquiring wings at the fifth molt. The life cycle requires from twenty-five to thirty days. There are probably four generations annually.

Injury to late celery is largely caused by the feeding of the adult bugs. These adults migrate into celery fields from weedy fields and waste land, where they have bred in great numbers. They attack the celery plants that are blanching and puncture the tender stalks, producing large brown wilted spots and a darkening of the tissue at the joint. This injury is known among celery growers as *black-joint*. Celery injured in this way does not keep so well in storage and its market value is greatly lessened. In the early crop the attack is of a somewhat different nature. In some seasons the bugs deposit their eggs in the early celery and the nymphs hatching from these eggs severely injure the hearts of the plants.

Control

DDT in the dust or spray form is known to give good control of the tarnished plant bug. It is much superior in efficiency to the sulfur formerly used to control this insect in the formula given above.

Somewhat of a health hazard might be involved in using DDT on celery. It would seem, however, that this should not be true if the celery were washed thoroughly with strong streams of water before it was sent to market. It should not be used within twenty-one days of harvest on celery that is to be stored and not washed.

A dust formula that has been used on celery to control tarnished plant bugs and blight is:

DDT—2 pounds actual (or 4 pounds of a 50 per cent DDT powder)
Metallic copper— enough to make 6 or 7 per cent in a finished dust or one of the carbamates, 10 per cent dust
Talc—enough to make the 100-pound mixture.

CARROT RUST-FLY

(See also page 38)

The carrot rust-fly may attack celery both in the seedbed and in the field if the plants are available during the egg-laying period. Celery seedbeds may be protected by screening with cheesecloth during the period when the flies are active, from about May 25 to June 10 in western New York. Protection is needed for seedbeds in which the plants are to remain after about June 10 to 15; where the plants are to be set before that date, screening is unnecessary. One should never use soil for a seedbed that is thought to harbor the overwintering pupae of the fly. Under such conditions, the screening of seedbeds may simply result in confining the flies in the bed when they emerge in spring, and thus cause more injury than when the bed is unscreened.

Where rust-fly injury is anticipated in celery seedbeds and screening is not prac-

ticable. 1 pound of pure flake naphthalene, when scattered over each 100 square feet of plant bed, is an effective repellent for the adult flies. This treatment is best made about May 20 to 25. Two or three applications made about one week apart will probably be advisable to afford complete protection.

Another insecticide that may prove effective in killing or repelling the flies in a celery seedbed is a 5 per cent chlordane dust. The same might be true of a 1 per cent parathion dust applied at weekly intervals.

BLIGHTS

Three separate and distinct blights, all controlled by the same means, attack celery and are characterized as follows: (1) early blight *(Cercospora apii)* produces dead, ashen-gray velvety areas; (2) late blight *Septoria apii)* causes brown spots on the leaves and the stems, in which are the tiny, black, fruiting bodies of the fungus; and (3) bacterial blight *(Pseudomonas apii)* produces spots that are more reddish brown than those of late blight, have a yellow halo about the lesion, and do not contain black fruiting bodies. Characteristic symptoms may appear on both the leaf blade and the petiole, or stalk, of the plant at any stage of its development. Plants in the seedbed as well as in the field are subject to attack.

The effect of the celery blights is to lessen the attractiveness of the product and thus to decrease its market value. When present to any extent, celery blights also retard growth, materially reduce the yield, and lessen the keeping quality of the celery crop. All of them live over from year to year in the diseased portions of the plants which remain in the field after the marketable celery has been removed, and also may be carried with the seed. In the field the three pathogens are spread readily by workmen, horses, or tools that brush against affected plants that are wet with dew and then against healthy foliage. Early in the season the incubation period of the causal organism is probably from a week to ten days, while later in the season it may be much longer. Infection of the leaves and the spread of the disease is favored by rain and by moisture on the plant.

Control

Soil for the seedbed should be selected from that which has not grown celery for at least three years, and which is free from celery refuse. This selection of the bed should be accompanied by thorough spraying with bordeaux mixture, 8–4–100, or dusting with 6 or 7 per cent insoluble copper dust. Manzate, Ziram, and Zineb, 2 pounds in 100 gallons, and Orthocide 406, 4 pounds, are also recommended in a number of States. Weekly applications are made in the seedbed; applications at this time are most important. This is followed by spraying or dusting in the field.

It is recommended that spraying be started as soon as the plants become established in the field and continued throughout the season at intervals of a week to ten days, except in very dry seasons. In very wet weather, all the materials but bordeaux mixture should be applied at 5-day intervals. The spray or the dust should be applied to the plants just before cultivation, for, if any old diseased refuse is in the soil, the cultivator will drag it to the surface of the soil, where it will fruit and cause infection if the foliage is not protected. If the disease does not appear three weeks prior to harvest time, continued spraying probably is not essential.

Even though spraying is done, as long rotations as possible should be practiced, and the diseased refuse left in the field should be plowed under deeply. Cultivation or other work among the plants should be delayed until after the dew is dried, especially if any infection is already present.

Seed that is more than two years old needs no treatment. New seed, if suspected of being infected, can be soaked either in hot water for 30 minutes, at 118° F., or

in formaldehyde solution 1 to 120 (½ ounce to a scant 2 gallons of water) for 30 minutes following a half-hour presoak in lukewarm water to soften the fungus, and followed by a brief rinse in tap water. Where seed is commonly soaked several days or sprouted before sowing, the fungicidal treatment has been found least injurious when given after two or three days of soaking but before any sprouting has occurred. Probably more reliance should be placed on thorough seedbed dusting or spraying than on seed treatments for blight control.

A resistant variety, Emerson Pascal, is now available and should be tried where Cercospora or Septoria has been destructive.

STORAGE ROTS

Late in the season a pink moldy rot of the stalks sometimes appears in the field or more often a little later in the trenches or in storages about seven weeks after harvest where it takes the form of a soft butt rot *(Sclerotinia sclerotiorum)*. On cold-storage celery, the color of this rot may be light brown with a gray mold on the outside *(Botrytis vulgaris)*, or it may be a deep bluish green, nearly black, sometimes a pink margin *(Phoma apiicola* or *Centrospora acerina)*. Not infrequently the rot is a soft mushy bacterial rot *(Erwinia)* and appears further up on the stalks and even on the leaves in the crate. All indications point to the field as the place of origin of these rots. Certain fields may gain a reputation for producing crops that have a very short storage period because of the presence of one or more of the three rot-producing fungi. Although no symptoms may be visible at the time of harvest, it is believed the fungi gain entrance through the roots or the cut surface.

In rare instances the Sclerotinia fungus may cause a severe damping-off of celery seedlings, and likewise under prolonged wet cool conditions in the spring the Phoma may cause considerable rotting of the roots of young transplants in the field.

Control

Long rotations to starve out these fungi, deep plowing to bury their fruit bodies and promote their decay, and sterilization or changing of soil in the seedbeds are the only economical means of control. It is important to keep a close watch on cold-storage celery and to market it in a week or two after the first symptoms of butt rot appear. A storage temperature of 32° F. helps to hold back the progress of decay where it is possible to maintain the temperature.

YELLOWS OF CELERY

Plants affected by yellows (caused by *Fusarium* sp.) are stunted, yellowish, and the tissues tend to be brittle and bitter in taste. A longitudinal section of the stem at the crown of the root shows the vascular tissue yellow or red. In severe cases the discoloration extends as far as the leaf veins.

The fungus accumulates in the soil with repeated croppings of celery. It is most destructive during warm seasons.

Control

Turning to resistant varieties has proved a most satisfactory way to stop losses from this disease. All of the dark-green varieties of celery, such as Giant Pascal, Utah, and Columbia, are fairly resistant to yellows. Among the varieties that have been bred or selected for resistance are Michigan Improved Golden, Emerson Pascal, Golden Pascal, Masterpiece, Kilgore's Pride, Easy Blanching, Woodruff's Beauty, Supreme Golden, Cornell No. 19, Emerson Pascal, and Cornell No. 6. Other varieties that can be grown in cool seasons or as early celery with only slight to moderate infection are Golden Prize, Golden Plume, and Early Fortune.

Growing resistant varieties does not seem to reduce the amount of the fungus in the ground, so that even after several years it is unsafe to go back to the growing of susceptible varieties again.

BROWN SPOT

Since certain strains of Utah celery have been introduced into the State, brown spot, caused by *Cephalosporium apii*, has become an annoying trouble in celery fields.

Irregular tan to brown shallow lesions are formed on the stems and petioles. The spots may be very small or joined together and produce a cracked brownish area one or more inches in length. These elongated areas are more likely to appear on the inner curve of the stalk. Rarely curling or distortion of the stem takes place. The cracked area somewhat resembles the injury when boron is lacking. The affected part does not penetrate much below the outer layer of cells, but the unsightly condition reduces salability.

The disease is most prevalent during a season of high temperatures and may be almost entirely absent during a cool summer. The optimum temperature for growth of the fungus is 75° F. It probably also is favored by wet weather.

Control

Although too little is known of the fungus life history, the general control measures of crop rotations, suitable drainage, and destruction of nearby perennial weeds are recommended. Other fungi of this group are sensitive to the toxic effects of the carbamates. Therefore, spraying or dusting at frequent intervals with Ziram or Manzate is suggested.

Eastern Pascal and Utah 10 B are most susceptible and should not be grown where the disease has occurred in previous years. Such varieties as Cornell 19, Emerson Pascal, and Golden Self Blanching are readily infected in the greenhouse but have not shown the disease in the field. Utah 5270 is most resistant but is not always suitable commercially. Utah 15 and Utah 16 are resistant and can be grown where the disease is prevalent.

VIRUS DISEASES

Eight or ten virus diseases have been reported on celery, but only two or three are of importance in New York State. The foremost of these is the cucumber mosaic virus. It usually does not cause distinct mottling, but the leaves have a grayish cast, tend to be narrow in width, and the whole plant is more or less dwarfed. The number of infected plants in a field varies from only a few to almost the entire crop. When so many are affected, the original source of the inoculum ordinarily is near or in the seedbed.

The other celery mosaic usually present produces distinct mottling and not such severe plant stunting as does the virus mentioned above. Its actual identification is not known at present. It may be the same as is known in California as Western celery mosaic.

Rarely a strain of aster yellows, spotted wilt (page 95) or celery calico also may attack the crop.

Control

The seedlings should be grown away from the flowers and weeds enumerated under cucumber mosaic (page 55). If possible, the perennial weeds along ditch banks, roadways, and fence-rows should be eradicated if conditions are such that some chemical as drastic as Brush Killer or Ammate can safely be applied to them.

CRACKED STEM

(Non-parasitic)

On many varieties of both early and late muck-land celery, a severe transverse multiple cracking of the epidermis, chiefly over the ribs or vascular bundles, that results in a ragged saw-tooth appearance of the stalks and that gives rise to such names as "rust" and "cat's claw," may render celery unmarketable. It is worse on new muck or in dead furrows, or after deep plowing or heavy liming. Recently, it has been shown to be due to a lack of

available boron. Thrips injury resembles the early stages of cracked stem but the lesions are between the vascular ridges rather than on them.

Control

Light applications of borax have given good control. The amount should be regulated carefully as too much causes severe injury; from 15 to 30 pounds an acre in one application is safe and adequate. It may be mixed with the fertilizer, dissolved in the liquid fungicide, or mixed with the dry fungicide used for blight control, or it may be applied directly as a side-dressing in mid-season. One application in two years is believed adequate, and after two or three have been made it may be wise to wait until symptoms appear before repeating.

BLACK-HEART

(Non-parasitic)

Tipburn of the central heart leaves followed by drying, blackening, and in some cases by secondary wet soft-rot, may cause sudden and severe losses at any time after the plants are 6 or 8 inches high. The cause of the breakdown of the fast-growing leaf tissue is not due to any organism but is associated with environmental factors, chief of which are high temperatures and humidities probably during cloudy weather and in the presence of high soluble salts, especially nitrogen. The humidity is usually occasioned or accompanied by excessive soil moisture. Black-heart can be brought on in 48 hours by flooding, and it is usually worse in low spots. There is some difference in varietal susceptibility.

Control

Choosing suitable varieties and providing adequate drainage to lessen the chances of excessive accumulations of soil moisture, irrigating at regular intervals in dry seasons to prevent irregular growth, avoidance of excessive amounts of nitrogenous fertilizers, and cutting the crop as soon as mature help to keep down black-heart.

CUCURBITS

Not a few of the insect pests of cucumber, squash, and melon plants need to be controlled regularly and thoroughly to insure a good crop. Two kinds of cucumber beetles, the spotted and the striped, are pests, and of these the striped cucumber beetle is destructive as a feeding beetle and a boring larva; moreover it spreads some plant diseases. The vine borer is a major pest of some varieties of squash as it kills the vines when present in some numbers. Stink bugs suck the sap from squash foliage to the point where plants die if the bugs are not controlled. Several kinds of aphids may also develop to destructive numbers on cucurbit crops.

STRIPED CUCUMBER BEETLE

The striped cucumber beetle (*Diabrotica vittata* Fabricius) is without doubt the most important insect enemy of cucumber, melon, squash, and related crops with which the growers of New York have to contend. Not only does the insect cause direct serious injury to the plants from the feeding of the adults and the larvae but indirectly it causes even greater loss by aiding in the transmission of two serious plant diseases — wilt and mosaic.

The cucumber beetle hibernates under trash and in patches of woodland, often at some distance from the fields in which the insect bred. The beetles emerge from hibernation early in the spring and feed for some time on the leaves and the flowers of various wild plants. They congregate on cucurbit plants just as they are coming up. They feed on the leaves and gnaw holes in the stems near the surface of the ground. Many plants are killed

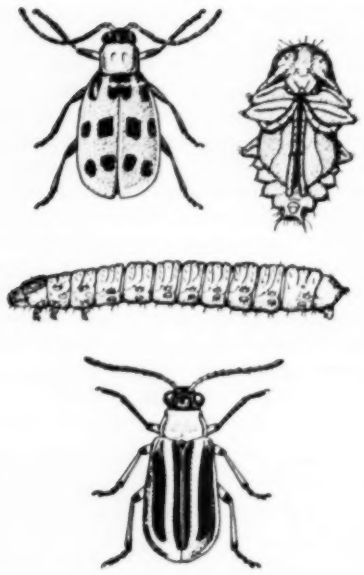


FIGURE 13. CUCUMBER BEETLES

Top and *center:* spotted cucumber beetle (left), pupa (right), and its worm-like larva (center); *bottom,* striped cucumber beetle

outright and others are so badly injured that they make only a sickly growth. The most serious injury is usually done before the plant acquires three or four leaves, but the beetles are present and troublesome for a month or longer in the early summer. On squash and melons the leaves may have a lace-like appearance when the beetles feed on a plant in large numbers.

The beetles deposit most of their eggs in crevices in the ground near the base of the plants, but some are dropped at random wherever the female happens to be. The eggs hatch in about a week, and the slender, white larvae burrow into the under-ground stems or into the vines where they rest on the ground. Sometimes the main stem just below the surface of the ground becomes riddled with the burrows of the larvae, and the plant becomes seriously weakened or even killed. The larvae become full-grown in about a month, and the new crop of beetles appear in August or September. This new brood of beetles sometimes scars growing or ripening melon fruits as they feed upon them.

Control

Both dusts and sprays are effective in controlling the beetles, but most growers prefer a dust because the dust residue left on the treated plants has some repellent effect. The applications, whether they be dust or spray, need to be repeated once a week or oftener, to protect the new growth of young plants which the beetles find unprotected and upon which they feed.

A ¾ of 1 per cent rotenone dust is effective, particularly if the entire field is dusted during one day or a part of a day. A 1 per cent parathion dust is somewhat better because it gives a quick kill and has some residual effect. A 10 per cent calcium arsenate is an effective stomach poison. A 1 per cent TEPP dust may be found effective.

The dusts should be applied by a bellows type of duster, or on large acreages with a power duster. About 35 pounds are needed per acre unless the plants are small.

Sprays can be used in place of dusts. Four pounds of 4 per cent rotenone powder, or 1 pound of 15 per cent wettable powder of parathion, or 2 pounds of calcium arsenate, each in 100 gallons of water can be used. A parathion emulsion or a TEPP emulsion will also be found effective if used at manufacturer's directions.

In some cases a grower will want to include a fungicide, such as zerlate, with the insecticide. He can usually purchase such a mixture under the label of *melon dust* or *melon spray*. Refer also to cucurbit disease control (page 51).

Probably the best time of day to spray or dust to control these cucumber beetles is early in the morning or in the evening, because the beetles are not so active as

during the heat of the day. Active beetles take flight readily at the approach of a spray or dust machine and its operator, and consequently are more difficult to kill with a contact insecticide. If a calcium-arsenate spray or dust is used, the treatments can be given to advantage any time of day except when there is much breeze or a wind, because the calcium arsenate has a residual poisoning effect.

Although DDT in either the spray or dust form controls the striped cucumber beetle, it is unsafe to use on melons, cucumbers, or squash plants because some forms of the DDT stop the growth of some varieties of these plants especially if the applications are made too frequently.

MELON APHID

While several species of plant lice occasionally attack cucurbits, the greater part of the injury in New York is caused by the melon aphid (*Aphis gossypii* Glover). The melon aphid passes the winter, in the northern part of its range at least, in the egg stage on orpine, or live-forever. The lice develop on this plant early in the spring and then, when winged forms are produced, migrate to cucumber and melon. The time at which cucurbits are attacked varies considerably, but in New York it is usually rather late in the season. The lice congregate on the underside of the leaves, causing the leaves to curl downward, turn brown, and die. In severe infestations the vines may be killed or so injured that the crop is small and of inferior quality. Furthermore, the lice are instrumental in spreading certain plant diseases from plant to plant.

Control

The melon aphid is controlled easily if it is wet by one of the contact sprays. Any difficulty encountered in its control is due to the inability of the spray to reach the underside of the leaves where these insects usually feed. The liquid spray is applied most effectively when a pressure of 400 pounds is used, which blows the infested leaves to one side or causes the spray to be forced back to the nozzle and in an upward direction.

Sprays that are effective are nicotine sulfate, 1 pint or more to 100 gallons of water plus from 2 to 4 pounds of a potash fish-oil soap, or a synthetic proprietary spray containing rotenone extract diluted according to manufacturers' directions. A dust substitute is a 2- or 3-per-cent-nicotine – lime mixture applied on a hot quiet day with a muslin or canvas trailer attached to the row crop duster so as to confine the fumes for 45 to 60 seconds over the plants to be treated.

Other sprays and dusts that will control the melon aphid are discussed under the control of the cabbage aphid (pages 29 and 30).

SQUASH BUG

The squash bug (*Anasa tristis* De Geer) is usually a troublesome if not serious pest of squash and pumpkin. The adults and their immature forms known as *nymphs* suck the sap from the leaves causing them to wilt and die. Because of their somewhat objectionable odor, they are known as stink bugs.

The adult squash bug is about ⅝ inch in length and is dirty brownish black in color above and brown, mottled with black, below. The adults hibernate in dry sheltered places and emerge in the spring to attack cucurbit plants as soon as they come up. The female deposits her rather large, brownish eggs in regularly arranged patches on the underside of a leaf. The eggs hatch in from six to fifteen days. When first hatched, the young bug is brightly colored; after the first molt, it becomes light dusty gray in color, almost white. The nymphs feed in colonies on the underside of the leaves, causing the leaves to wilt, curl up, turn brown, and die.

Control

The number of bugs on plants in early summer can be decreased materially if the

plants of the previous season are destroyed or plowed up just after the crop has been harvested. This treatment often prevents many of the bugs from reaching the adult stage, and it is only in this stage that the insect can pass the winter. This destruction of infested plants in early fall will effect some control, especially in garden plantings.

Under garden or small-sized planting conditions, it is often practical to trap the grown bugs as soon as they appear on young squash or pumpkin plants, if a wooden shingle or similar board is placed on the ground at the base of each plant. The bugs collect under such boards at night and can be gathered and killed readily the next morning before they become active.

It is not advisable to use DDT to control squash bugs because of the danger of stunting the plants (page 47).

Heavy infestations of bugs can be controlled with a pyrethrum dust or spray. Rotenone insecticides are effective only against the young and smaller stages of this insect. A suitable pyrethrum powder in the dry dust form is one that contains from 0.5 to 0.9 pyrethrins. An impregnated pyrethrum dust containing from 0.2 to 0.3 pyrethrins is equally effective. A 1 per cent parathion dust is also effective. Regardless of the dust used, none will be entirely satisfactory unless the treatments are repeated with some regularity, and in the case of pyrethrum and rotenone the bugs must be actually coated with the dust. The duster should usually be fitted with up-turned nozzles.

Effective sprays are those discussed for the control of the cabbage aphid on page 29. Here again the bugs must be hit with the spray except possibly in the case of parathion which appears to have some residual effect.

SQUASH VINE-BORER

One of the most troublesome insect enemies of squash and pumpkins is the squash vine-borer *(Melittia satyriniformis* Hübner). When fully grown it is an inch in length and has some resemblance to a rather fat, cylindrical, creamy white grub. This borer is the larva of a day-flying moth which, when on the wing, is easily mistaken for a wasp. The moth deposits her eggs on the stem of the plant, and the young borer penetrates the vine and burrows through the stem or runner, usually towards the base. The burrows of the larger larvae are usually wet, slimy, and partly filled with excrement; decay often ensues and hastens the death of the vine. When mature, the borer leaves the stem and enters the ground an inch or two for pupation. On Long Island there is one brood and a partial second, while farther north there is only one generation a year.

Control

Cultural Control

This borer may be held in check by practicing such of the following methods as are warranted by the severity of the outbreak and by other local conditions. Since the insect passes the winter in the ground, it is not a good policy to grow squash in the same field year after year. If for any reason it is necessary to raise successive crops of squash on the same ground, the land should be harrowed in the fall, to expose the cocoons, and then plowed deeply the following spring. The vines should always be collected and destroyed as soon as the crop is harvested, to prevent the late caterpillars from reaching maturity.

In some localities the use of early squash as a trap crop has been attended with success. A few early squash, such as crooknecks, are planted early around the field and between the rows of the late varieties. The moths will deposit their eggs on the early squash, and the main crop, coming up later, will escape the greater part of the infestation. As soon as the early squash are harvested, or sooner if they crowd the main crop, the vines should be pulled up and burned or composted, in order to kill the borers they contain.

After the borer has once entered the vine, there is nothing to be done but to cut it out with a knife. If care is taken to make the cut lengthwise of the stem and if the vine is immedately covered with earth at the injured point, the wound soon heals and the vine continues its growth. Some growers make a practice of covering the stem with earth 2 or 3 feet from the base, to make the vine throw out a new root system which will sustain the plant in case the main stem is injured at the base.

Control by Sprays or Dusts

Spray and dust tests conducted in many successive seasons have shown that this borer may be prevented from inflicting commercial injury if the vines are treated four times during the growing season at an interval of seven days with a rotenone, nicotine, or parathion insecticide as described on page 46 for the control of the striped cucumber beetle.

In recent years the first of these treatments has usually been found advisable in upstate New York about June 25. This first spray or dust treatment should be applied about 5 days earlier in the Hudson Valley. County agricultural agents are usually kept advised as to when the first of the four treatments should be made, and they should be consulted by growers who desire to make a serious effort to control this insect.

Although a 3 per cent DDT dust or its equivalent in a spray has been found effective against the vine-borer, it is not safe to use this insecticide on squash except possibly on those of the Hubbard type; for injury is apt to result.

ANGULAR LEAF-SPOT

Angular leaf-spot (caused by *Pseudomonas lachrymans)* used to be common and destructive in most of the older cucumber-growing districts, but persistent control measures have almost eliminated it from the State. It affects cucumbers, certain gourds, and a few less-known plants of the same family. On squash the

FIGURE 14. ANGULAR LEAF-SPOT ON A CUCUMBER LEAF

angular leaf-spot is caused by *Xanthomonas cucurbitae,* which has almost the same symptoms, life history, and control as the bacterium on cucumber.

The disease appears on the leaves, the stems, and the fruit. The spots on the foliage are irregular in shape, angular, and have a water-soaked appearance. In the presence of moisture, bacteria ooze from the spot in tear-like droplets, which dry down into a white residue. The water-soaked area later turns gray and dies. The drying and shrinking of the dead tissue may tear it away from the healthy portion, leaving large irregular holes in the affected leaves. The spots of the fruit are much smaller and nearly circular. When the diseased portion dies, the tissue becomes white in color and may crack open.

The bacterium that causes the disease overwinters in diseased plant refuse and on the seed. During rains it is splashed from the soil to the stems and the leaves, and later to the fruit. After infection has once taken place, the organism is transferred readily on the hands and the clothing of the pickers. Infection takes place through the stomata, and, since they close during the night, most of the entrances by the bacteria take place in the early morning after daylight but before the dew or the rain has evaporated. Inoculation may take place on the fruit just before picking. If such cucumbers are shipped long distances, much spotting may appear during transportation on fruit that apparently was healthy when picked. Frequent rains and a temperature of 75° F. are optimum conditions for the growth of the bacterium.

Control

Control methods are similar to those recommended for the control of cucurbit anthracnose, except that Ziram is not nearly so effective in sprays or dusts as is copper. Consequently, either the low-soluble copper as a spray or dust or bordeaux mixture should be applied every five to seven days as long as the temperature remains high enough for angular leaf-spot to cause infection. If both anthracnose and angular leaf-spot are present, the Zerlate (or other Ziram) and copper applications should be alternated.

ANTHRACNOSE

Anthracnose (caused by *Colletotrichum lagenarium)* is usually present on watermelons, and to a lesser extent affects also muskmelons, gourds, and cucumbers. Squash and pumpkins are almost immune. The fungus produces angular black spots on the leaves and elongated black spots with light-colored centers on the petioles. The small fruits are sometimes killed, after which they turn black and drop off. The older fruits have dark bordered cankers with flesh colored ooze in the center. Soft rots may follow these depressed cavities. Resistant types of muskmelons may show pimples instead of cankers.

The fungus lives overwinter in diseased melon and cucumber refuse, as well as in and on the seed. When contaminated seed is planted or old vines are present, the fungus is splashed to the new plants where it may become destructive when weather conditions are favorable. The fungus requires a fairly high temperature and plenty of moisture for most rapid growth.

Control

The control methods are similar to those recommended for the control of cucurbit scab (page 52) except that seed treatment will not kill fungous threads that have grown into the seed.

None of the copper compounds are effective against anthracnose, so Ziram, Manzate, or Orthocide 406 is recommended and has proved much better than copper. Two pounds of the former material or 4 pounds of the 406 are mixed into 100 gallons of water, to which a pint of some commercial spreader has been added. When downy mildew also is to be controlled, it may be necessary to alternate one of the above sprays with copper. If

an insecticide is required, it should be added according to the directions of the entomologists.

If a dust is used, 10 pounds of Zerlate, Manzate, or Orthocide 406 is mixed with 10 pounds of flour and enough talc to complete 100 pounds. To this should be added the insecticide recommended by the entomologist. This dust now is on the market already prepared, and is preferable to incomplete home mixing.

If bacterial wilt is not a problem, the only dusts or sprays needed the first two weeks after the plants are up are those recommended for insect control. If bacterial wilt has caused injury in previous years, it is advisable to apply the fungicide with the insecticide as soon as the plants are up. Two applications are necessary the first week. After that, weekly applications usually are enough. During this early growth of the plants, it is more satisfactory to use hand dusters than either sprayers or horse-drawn dusters. Only a few pounds of dust then are required to cover an acre of young plants. It should be emphasized that a light coverage is enough. A heavy dosage may cause injury. Usually, plants require protection only during the first five to six weeks, unless rotation is not practiced or the crop is grown near diseased vines.

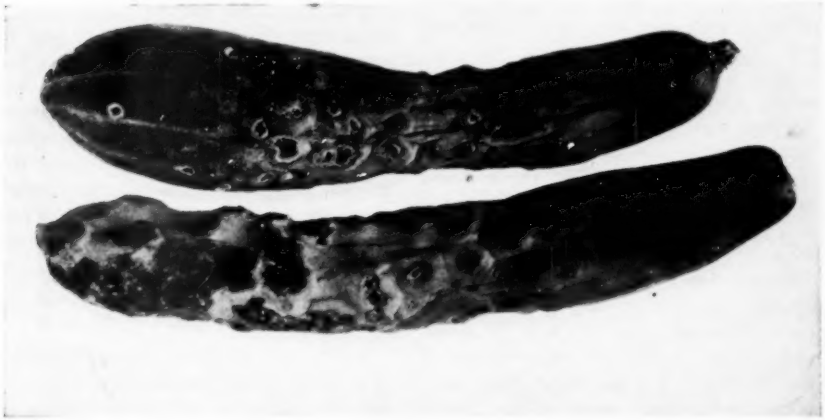
If desirable, the dusts may be replaced by sprays after the first three or four applications. If late applications are made, the material should be put on directly after the picking, so the fruit will not be spotted too much. Vines are injured by much trampling, so care should be taken when working in the field. After the plants have some size, a horse-drawn or power sprayer or duster is more convenient and economical in large fields than is a hand machine.

Angular leaf-spot can be controlled completely in seasons of low temperature by treating the seed with corrosive sublimate, and two-year rotations. Anthracnose and leaf blight are only partly controlled by these two practices, so spraying or dusting in the field is essential.

SCAB, OR POX

Scab (caused by *Cladosporium cucumerinum)* occurs on cucumbers, muskmelons, pumpkins and sometimes squash. The affected leaves have water-soaked spots which later turn white and are distinctly angular in shape. Most of the dead tissue finally tears out and leave a shot-hole

FIGURE 15. CANKERS ON CUCUMBER FRUIT CAUSED BY SCAB



effect. The stems also have slight cankers, but most of the injury is on the fruit, where at first there is an oozing of sap, as if there had been an insect sting. Later the spot increases in size and becomes a sunken cavity lined with an olive-green mold. The fruit finally may be destroyed by a soft rot. The winter squash, because of its resistance, may sometimes show only elevated calluses.

The scab is caused by a fungus that lives over in old cucumber refuse, in the cracks about the greenhouse, and on the seed. It develops best in moist air and can cause infection at temperatures as low as 51° F.

Control

A few helpful suggestions include eradicating weeds in the field and plowing under diseased vines immediately after harvest. But the two important recommendations are crop rotations and seed treatment. The cucumber or the other cucurbit seeds are tied loosely in a cheesecloth bag and are dipped for five minutes in a corrosive-sublimate solution (1 tablet in each pint of water required; or 1 ounce of the powder dissolved in a little hot water and then enough cold water is added to make 7½ gallons). The temperature of the solution should not be lower than 60° F. nor warmer than 80° F. The seeds are then rinsed thoroughly in clean water and dried, or they may be planted while still wet.

After the seed is dry, and immediately before planting, it is coated lightly with Semesan dust according to the directions on the label or with Spergon, ½ level teaspoonful to 1 pound of seed. The seed and dust are placed in a tight container, such as a glass fruit jar, and shaken for several minutes.

In addition to seed treatment and crop rotation, spraying or dusting as suggested for anthracnose (page 50) may be necessary. When minimum temperatures of less than 57° F. last longer than nine hours continuously, none of our known fungicides are effective. This happened in 1951.

LEAF-SPOT

The leaf-spots on cucurbits (caused by *Macrosporium cucumerinum*) at first are small, circular, and somewhat water-soaked. They enlarge rapidly, and may be recognized easily by the concentric rings and a definite margin on the upper side of the leaf. When enough spots are present, the foliage dies. The fungus lives over in the old plant refuse, and during the summer is splashed by rains or carried by tools from one plant to another. It may possibly be carried in the seed, though this has not been proved. Leaf spot is especially severe in warm moist seasons, as was true of 1938. It usually occurs in epiphytotic form only where there are enough weeds in the field or there is a windbreak, so that the dew in the morning remains on the plants for a long while.

Control

The same control measures are suggested as for cucurbit scab and anthracnose (pages 52 and 50).

POWDERY MILDEW

The powdery mildew (caused by *Erysiphe cichoracearum*) affects melons, cucumbers, squashes, pumpkins, and nearly every other kind of cucurbit, as well as some unrelated plants. The fungus appears as a white mealy growth on the upper side of the leaves. When the fungus grows luxuriantly, the foliage withers and dies. It is not known definitely how the mildew lives over the winter, or whether it can be disseminated with the seed. Its growth is favored by high temperatures and absence of dashing rains.

Control

The usually suggested means of control is to spray or dust the plants as suggested for the control of anthracnose (pages 50

and 51). Seemingly only the wet form of the copper fungicide is effective. Sulfur is more toxic to the powdery-mildew fungus than is copper, and can be applied in dilute form by mixing 20 pounds of fused bentonite dusting sulfur with 80 pounds of the cucumber-melon dust and applying lightly once or twice after mildew appears.

In several States a material known as Mildex, Iscothan or Karathane, ¼ pound in 100 gallons, has been applied successfully to control powdery mildew on vegetables. Godfrey used it on melons in Texas. Injury may result if the foliage is wet or if much of the material is used.

In the Imperial Valley of California, resistant melons have been bred that are suitable for their climate. The same melons are, however, of no value for up-state growers.

DOWNY-MILDEW

The downy-mildew, or blight, (caused by *Pseudoperonospora cubensis)* may be destructive on Long Island if weather conditions are right, and recently has become prevalent in up-state New York. It affects not only cucumber, squash, pumpkin, and muskmelon, but also a number of other closely related plants.

Irregularly shaped yellowish spots appear on the upper sides of the foliage, usually on that nearest to the center of the hill. If the leaf is examined on the opposite side when dew or rain is present, the brown lesion will be covered, or at least bordered, by a purple fungous growth. The spots increase rapidly in size until the whole leaf withers and dies. In a badly diseased field it is not uncommon to find all the foliage dead near the center of the hill, with only the young leaves remaining at the tips of the vines. If fruit is being formed during the attack, it will remain dwarfed and have a poor flavor. Cucumbers so affected are known as *nubbins.* The fungus requires much moisture, accompanied by high temperatures for best development. It is not known how it lives over during the winter, nor is it known to be carried in the seed.

Control

Long rotations and plowing under diseased vines immediately after harvest are usually recommended as precautionary methods. The principal control measure, however, is repeated and thorough applications of bordeaux mixture, Manzate, or one of the Zineb type of sprays. Two applications a week are required if the last two are used. Ziram and Orthocide 406 have not proved effective. Copper, Manzate, or Zineb dusts also may be applied.

BACTERIAL WILT

The bacterial wilt (caused by *Erwinia tracheiphila)* is one of the more serious troubles of cucumbers, squashes, muskmelons, and pumpkins.

The disease starts on a single leaf, which gradually wilts and dies. The wilting spreads to the vine and finally to the whole plant. In certain squashes that are rather resistant there is no true wilting but a distinct dwarfing of the vine. If an affected stem is cut crosswise and some of the plant juice pressed against the finger, the juice sometimes will string out if the finger is withdrawn slowly. The sap of the healthy plant is watery and usually does not string. Drops of bacterial ooze may collect on the surface of the fruit. The roots are not affected directly.

The disease is caused by a bacillus that can overwinter only in the digestive tracts of the striped and the twelve-spotted cucumber beetles. In the spring the parasite is deposited on the cucurbit leaves in the droppings of the beetles. It enters the host tissues only through deep feeding wounds that penetrate the sap ducts, and finally migrates to all parts of the vine. It is disseminated to other plants by deep-feeding insects and by pickers. Late in the season grasshoppers are effective carriers.

The weather conditions seem to have little to do directly with the increase or the decrease of the disease. Any environ-

ment that favors the feeding of the beetles, such as moderately high temperature, naturally greatly affects the number of later infections. In the winter of 1944–45 when the snow was unusually deep, followed by exceptionally warm weather in March and April, insect carriers were so numerous that the wilt appeared almost in epiphytotic severity.

Control

A few plants in the garden may be protected by inclosing them in cheesecloth tents. Specially prepared sticks or wooden barrel hoops cut in halves are placed at right angles to each other, and their sharpened ends are inserted in the ground. The cheesecloth is stretched over the hoops and its lower edges are weighted with stones or soil so that no insects can crawl under the covering. Large plantings of cucurbits must be protected by insecticides and fungicides. The same dust or spray schedule is required as that suggested for the control of cucurbit beetles (page 46) and of anthracnose (page 50). Early applications of copper are most important in the control of wilt.

The American varieties, such as Chicago Pickling, and other related Pickling strains are much less susceptible than are similar varieties originating in Europe, such as Half Long Prolific, Oblong Green Pickling, King William, Short Green Parisian, and others. Where wilt has been severe, the American varieties should be chosen even though they are far from immune.

STEM STREAK OF MUSKMELON

Stem streak of muskmelon has also been known as *Marssonina blight*. It is caused by a fungus named Cephalosporium sp. or *Venturia cucumerina*. It causes pink to brown streaks or spots on the stems and petioles. The affected stems may finally be girdled so that the whole vine dies. In wet weather such vines may be covered with fungus growth. The disease can appear at any time in the life of the plant but is more generally prevalent about the time the first melons are ready to be picked. The entire field may be made worthless within a few days.

The fungus is not a very virulent pathogen on normal plants, but when there have been heavy rains for a few days, if Verticillium wilt is present or the crop weakened in any other way, the fungus gains an entrance and then is able to do much damage. It grows on many crops and weeds so that inoculum constantly is present to cause infection when conditions are favorable. In addition to water-soaked tissue, the pathogen requires a relatively high temperature. The optimum is about 75° F., which is a high average in New York State.

Control

Crop rotation, destruction of nearby weeds, well-drained soil, and favorable growing conditions for melons are of special importance in combating this destructive disease. The fungus is more sensitive to Ziram than to copper, so that frequent sprays or dusts should be made as suggested for the control of anthracnose.

Breeding for resistance is underway and finally suitable strains may be available.

MOSAIC

Mosaic (caused by a virus) is one of the most threatening of all the diseases of cucumbers, squash, and muskmelons. In some of the older sections the growing of these crops has become unprofitable, and the disease seems to be increasing in all the newer areas. If all growers do not take every precaution to eradicate the virus, the cucumber crop in New York State is almost sure to be much diminished unless suitable resistant varieties are found.

At least two distinct strains of the virus affect cucurbits. There is also another mosaic that is not virulent in nature.

On many kinds of cucurbits, ring spot

is a serious disease, and its symptoms on cucumber and muskmelon can be mistaken for the common mosaic. On squash fruit distinct rings are formed which serve as infection points for various organisms.

Slightly affected vines of cucumbers, muskmelons, and squash show the normal green of the leaf to be mottled with light yellow areas. The fruit, too, may be mottled, or have a much roughened surface caused by knobs of green, developing normally while the tissue between fails to grow. Sometimes the green color is almost totally lacking, and the disease then is known on cucumbers as *white pickle*. In severe cases the plants are yellow and very much dwarfed. Such plants bear little or no fruit.

The mosaic diseases are caused by viruses in the sap of affected plants. The ringspot virus overwinters in the seed of the petunia and probably is transmitted occasionally from soybeans to the vine crops, while that of common mosaic is present in the wild or bur cucumber, and in the roots of perennial plants, such as milkweed, catnip, mother-wort, pokeberry, ground cherry or husk tomato, phlox, plantain, holly-hock, wild bluebell, burdock, flowering spurge, and white cockle. When these plants come up in the early spring, the cucumber aphid, the striped cucumber beetle, and the twelve-spotted beetle feed upon them. The mouth parts of the insects become contaminated with the virus which they carry to cucumber, muskmelon, squash, or pumpkin plants. Within five to ten days the new infections begin to show. The disease may then be transmitted from plant to plant in the field by insects or on the hands of workers harvesting the crop. The virus of the virulent cucumber mosaic probably never is carried in the seed, but the milder type of mosaic virus is transmitted at least through muskmelon seed.

The alfalfa mosaic virus may cause symptoms much like the cucumber mosaic on cucurbit plants.

Control

The cucumber or melon field should be surrounded by cultivated crops other than soybeans and should not be near buildings, grainfields, hedgerows, vacant lots, or other places where the susceptible weed hosts grow undisturbed. The host plants that grow in the cucurbit field or within 50 yards of its outer edge should be pulled up and destroyed, or sprayed with a weed eradicant. Wild cucumber, mother-wort, and catnip are by far the most important of these in up-state New York. The field should be inspected for these weeds even before the cucumbers or the melons are planted, and the inspections repeated at frequent intervals during the growing season until there is no more danger from infection. This is not an easy task, but it is the only remedy where resistant varieties are not used. It would be a great help in weed eradication if the location of the cucumber or melon field were planned the fall before spring planting; for as soon as danger of injuring cultivated crops is passed the fence rows, ditch banks or fallow places where clumps of the carrier weeds are known to occur, could be sprayed with 2,4–D or other effective weed eradicant.

If infected plants are found in the crop early in the season, it may be well to pull them up at once and remove them from the field. It is doubtful, however, whether this roguing is of any value after the plants become nearly grown. Only that part of the plant that develops after inoculation takes place is injured much by the disease; therefore, if all early infections are avoided, the crop loss can be much reduced.

Seed treatment and spraying or dusting are of little or no value in mosaic control, except in so far as insect feeding is hindered.

Several States or companies have developed resistant strains such as MR 17, Early Sure Crop Hybrid, Sensation Hybrid, Ohio 31, and Burpee Resistant Hy-

brid. Dr. Munger of the Plant Breeding Department at Cornell has bred the Niagara, a slicing cucumber, and the York State Pickling, which should be grown wherever mosaic has been a problem.

FUSARIUM WILT OF MUSKMELONS

Fusarium wilt (caused by *Fusarium* sp.) apparently affects only muskmelons. It seems to be spreading rather rapidly in the Central and Eastern States. It is capable of destroying the entire crop on a farm when the soil once becomes heavily infested.

The plants first show a stunting or yellowing. About this time a streak begins to form along one side of the vine, and extends for a few inches or for the entire length of the plant. The streak at first is water-soaked, then becomes fawn colored or yellowish tan. In some plants there is no definite streak but the vine cracks open and sap oozes out and collects in amber drops. The plant soon dies. Infection takes place throughout the entire season.

The fungus lives in the soil for many years and also may be carried in the seed. High temperatures are favorable for its growth.

Control

Long rotations, sterilization of the soil in which the seedlings are grown, and destruction of diseased refuse are suggested precautions. The use of resistant varieties, however, is the only satisfactory control method. Plant breeders in New York and Minnesota have developed marketable melons resistant to this disease. Where only heavily infested soil is available, plantings of Iroquois, Delicious 51 or Golden Gopher should be made to test the suitability of these strains on the individual farm.

MALNUTRITION OF MUSKMELONS

Malnutrition (cause unknown) was called to the attention of the plant-disease specialist in 1930. At that time it seemed rather prevalent in Niagara County and later was observed in many localities north of the Ridge between Rochester and Chautauqua County. The extent of affected plants ranged from a trace to 100 per cent in the fields that were surveyed. A similar trouble was found on a few farms in Albany and Schenectady Counties.

The affected plants are prominent because of their light green or yellowish green color as contrasted with neighboring dark green healthy plants. The length of the vines usually is normal except in the more pronounced cases, or particularly when the injury occurs on plants soon after the seedling stage. Under such conditions the stem may be much dwarfed. The plants blossom normally, but not so many fruits are set, nor does the fruit which develops grow so large. The taste of the melon too is insipid.

The injured leaves show a light green or yellowish green between the veins with a dark green line a millimeter or more wide on each side of the vein. The more severely affected, the narrower the dark green strip and the more likely it is that the smallest veinlets do not show any of this vein banding. In extreme cases all parts of the leaf are light green except along the midrib and the principal veins emanating from it. In the most pronounced cases all the leaves on the vine are affected; in others only the leaves nearest the base appear normal.

It has been proved that the trouble is not due to any virus disease, but is the result of faulty nutrition, possibly an excess of some mineral. Apparently, the melon is very susceptible to soils that are acid. In the Albany district, malnutrition occurs only where the sandy soil is extremely acid and is controlled by the application of lime. Most of the soils along Lake Ontario are not extremely acid, but the malnutrition is corrected by an application of lime, which makes unavailable injurious chemicals in the soil.

Control

Although the exact cause of this malnutrition has not been definitely solved, it has been observed in the fields that certain conditions reduce the injury caused by this trouble. If seeds are procured from sources where the injury is not present, the young plants seem to be more vigorous, and are later in showing the effects of the malnutrition. It also has been observed that when the soils test between pH 6.00 and 6.50 there may be less injury than when they test more acid. In nearly all cases where the injury is severe, the sandy soil has been depleted more or less of humus content. But the most important environmental factor is wetness of the soil. During dry weather, a field of melons may show extreme malnutrition injury and almost fully recover after a heavy rain. Therefore, the recommendations are: to buy seed that has been grown on normal soil, to select fields that are not too acid, to apply lime according to the directions of the county agricultural agent if the disease has occurred in the field before, to take every precaution to fill the soil with well-rotted humus, and, if possible, to water artificially the plants during periods of exceptionally dry weather.

EGGPLANT

FLEA BEETLES AND APHIDS

Flea beetles and aphids are sometimes injurious pests of eggplant. The tiny black beetles eat holes in the leaves, and the aphids suck sap from beneath the leaves to the point where growth of the plants is checked.

Control

The flea beetles can be controlled by following the directions given on page 88 for the control of this insect on tomatoes. Aphid-control directions are the same as those given on page 00 for this type of insect when it affects cabbage.

WILT

The fungus (caused by *Verticillium alboatrum*) that causes eggplant wilt affects many other cultivated and weed hosts. Among these are some as far apart in the plant classification as peaches, muskmelons, tomatoes, peppers, and black raspberries. The disease probably is present wherever eggplants are grown, and is so serious, when it once becomes well established, that in many localities the growing of the crop is no longer profitable.

The wilt starts early in the life of the plant but usually is not noticeable until the crop is fairly well grown. Then some of the plants may be smaller than the others, the leaves may turn yellow, then brown between the veins, so that the whole plant lingers half alive during the remainder of the season or wilts and dies soon. The tissue beneath the bark of the stem is discolored. The fruit is not affected, at least directly, by this disease.

It now is known that the pathogen is carried with the seed. After once being introduced the Verticillium lives for many years in the soil. It may be brought in with soil on the roots of transplants or in other ways in which soil organisms are disseminated. It appears not to be much affected by temperature but does require at least a moderate amount of soil moisture for best growth. It seems to thrive better in sandy soil or sandy loam than in heavy clay. But most important of all, the fungus grows best when the soil is alkaline, and grows only slowly when the soil is very acid.

Control

Seed treatment and spraying or dusting are of no value in controlling this fungus. Care should be taken to procure seed from disease-free fields.

When once the wilt has become generally prevalent in any given field, eggplant should not be planted in that field for many years. A new field should be chosen which for ten years or more has not produced wilt-infected raspberries, potatoes, tomatoes, or any of the other susceptible crops.

The application of sulfur to the soil has been suggested for the control of wilt. If other crops are to be grown on this land, the sulfur will prove harmful. Consequently, it would be better to use a different field each year for eggplant, choosing those with the most acid soils.

A few garden plants can be protected by sterilizing the soil with formaldehyde, acetic acid, or chloropicrin at least 2 weeks before transplanting time. Tomatoes, potatoes, cucurbits, and many other crops are so resistant that infection can occur only when the roots are broken after transplanting or after the soil has been saturated with water two or more days. Well-drained soil, therefore, is very important.

Breeding strains of eggplant for resistance has proved most discouraging, but there is some indication that breeding will be successful with tomatoes and muskmelons.

BLIGHT

Most of New York State is too far north for serious trouble with the blight (caused by *Phomopsis vexans*), but in certain seasons on Long Island and Staten Island the temperature reaches the height favorable for the growth of the fungus. So far as it is known it affects no other crop.

The fungus may cause trouble at any stage in the development of the plant from the damping-off of day-old seedlings to the rotting of ripe fruit. The young plants blacken and die. The leaves of older plants may be peppered with so many brown spots that they wither. The most serious phase of the disease, however, is the fruit rot. The fruit turns black, shrivels, and is covered with minute black pimples, which are the fruiting bodies of the fungus.

The parasite overwinters in and on the seed, as well as in old diseased refuse, and can remain alive in the soil for at least three years. Aside from the high temperatures, it is not much affected by environmental conditions. The more rainfall, the more chances there are of heavy infection.

Control

The first requirement in control is crop rotation of four or more years. An attempt should be made also to procure healthy stock. If the grower saves his own eggplant seed, these should be taken from fruits that are without blemish. Northern-grown seed is more desirable than southern seed, which is almost sure to be infected. Only bright-colored seed should be planted. If an appreciable proportion of the seeds show black spots, the whole lot should be discarded. Seeds of unknown origin should be treated by tying them loosely in cheesecloth and dipping the bag of seeds for 25 minutes in water heated to 122° F. The seeds are then dried, and before planting shaken in a tight container with red copper oxide, Arasan, or Spergon, 1 teaspoonful for each pound of seed.

The plants should be sprayed each week in the seedbed with Ziram or Orthocide 406, 2 pounds in 100 gallons. Similar applications can be made also in the field if the blight has appeared frequently enough to justify the expense. Then Manzate (2 pounds to 100 gallons) is especially effective.

Picking affected fruits as soon as the disease appears, and destroying them by burying or in some other manner, reduces very much the amount of inoculating material, and has helped to retard the spread of blight during the current season as well as to reduce the amount of disease the following year.

LETTUCE

LETTUCE LEAFHOPPER

The six-spotted leafhopper *(Macrosteles divisus* Uhler) is a carrier of a disease to lettuce known as *yellows*. The leafhoppers pass the winter in the adult stage on cover crops such as rye and on winter grain crops. They breed a generation on the crops in spring and then migrate to lettuce in June. When feeding on lettuce, they inject the yellows virus into the plants. The virus may affect the maturity of the plants seriously.

Control

Only a few leafhoppers need to be present in a field to bring about a yellows infection. Therefore, it is desirable that control treatments be started when the leafhoppers are first seen. This is likely to be about June 15 at which time a grower may have some early planted lettuce that is about mature and other later plantings. After leafhoppers are seen, all plantings should be treated with insecticides beginning when the plants are only an inch or less in height. This may be before the lettuce is blocked. The reason for the treatments while the plants are so young is that the infection can be caused at that time but it will not show in the plants until two to three weeks later.

A 5 per cent DDT dust containing preferably 1½ to 2 per cent of lubricating oil to make the dust heavy is an effective insecticide when used at the rate of 40 pounds per acre. A 1 per cent parathion dust is also effective.

Some growers have applied concentrate DDT sprays by aircraft or by low-gallonage low-pressure ground sprayers. In each case the object is to distribute about 2 pounds of actual DDT per acre uniformly at each application.

Three or four treatments at five- to seven-day intervals may be necessary to keep the leafhoppers under control to the point where yellows infection will be reduced materially at harvest.

DDT should not be used on lettuce within *fifteen* days of harvest. Parathion should not be used within ten days of harvest.

BOTTOM-ROT

Bottom-rot (caused by *Rhizoctonia solani)* is the most destructive rot of Boston head lettuce in this State. The rot starts where the bottom leaves rest on the ground, and generally works up into the head, destroying first the blades of the leaves and less rapidly the midribs, but never rotting off the main stem of the plant. It is caused by the very common and widespread fungus known as *Rhizoctonia,* which attacks the plants from the soil, and which is very destructive when the lettuce leaves and the supporting soil remain moist. The pathogen lives in the soil, on growing plants, and on diseased plant refuse. Its greatest period of development is after the healthy plants have been harvested and those with infection have been left to rot in the field.

Control

An important practice is long rotations with such crops as sweet corn, tomatoes, cucumbers, radishes, beets, onions, and spinach. If a field becomes heavily infested with bottom-rot, it may be advisable to plant some cereal or hay crop for a year or two.

All vegetable crops, particularly celery, carrots, and cabbage, should be harvested promptly and removed from the field so that no molds can reproduce on them. As soon as the lettuce crop is harvested, all the unused plants or other lettuce refuse should be hauled a considerable distance from the field and placed in a composting heap. Even though this entails much labor, it has proved very effective in holding back the disease on newly cleared muck where the fungus is not so abundant.

The moisture can be controlled somewhat by planting in well-drained soil, which received frequent shallow cultivations, and by eradicating the weeds in the field and along the ditch banks so that there can be good aeration.

Excellent results have been obtained by the use of dust for the control of bottom-rot. An ethyl-mercury phosphate dust, New Improved Ceresan, mixed with an equal amount of talc, is blown under the plants by a special lettuce duster. One application of 25 pounds of the material usually is enough if made two or three weeks before the crop is harvested. Where bottom-rot has been very severe, it may be profitable to make two applications at ten-day intervals, beginning a month before harvest.

Satisfactory strains of Iceberg lettuce that can be grown in this State are now available and are much less affected by bottom-rot than are other strains. Where the disease has been prevalent, it may be well to try recommended strains of this variety.

In greenhouses, the bottom-rot can be controlled by soil sterilization.

DROP

The lettuce drop (caused by *Sclerotinia* spp.) is mostly a greenhouse trouble, although it may be found also rather commonly in some fields. The rot begins on the stem near the surface of the soil, and rapidly spreads upward, killing the leaves in succession, until it reaches the heart of the plant. The dead tissue changes to a wet, slimy, decayed mass. The white fungus may grow over the entire plant, and also form many black, variously shaped sclerotia, which are the resting bodies. The pathogen remains alive in the soil for a long time, and reproduces rapidly in the lettuce refuse left in the field or in the beds where it is grown. The same fungus attacks nearly all other kinds of vegetables, especially carrots, cabbage, and celery.

Control

The recommendations for the control of drop are similar to those for bottom-rot (page 59). In the field, a three-year rotation with nonsusceptible crops such as hay, corn, cereals, onions, or even beets and potatoes is the most practical way to reduce drop to a minimum. Recently, dusting three times at ten-day intervals with a material containing 7 per cent of metallic copper (one of the insoluble copper compounds) gave favorable results in the field. Dusting is begun when plants are half grown. There is some indication that in the field dusting with Tersan diluted with an equal amount of talc reduces the amount of drop. When plants are grown in coldframes, the sash manipulation should be similar to that suggested for the control of downy-mildew (page 63).

In Arizona, where sheep were permitted to pasture in harvested lettuce fields, the amount of drop was reduced the following year. Less than 1 per cent of the sclerotia that passed through the digestive tract of the animals remained viable.

TIPBURN

Tipburn (caused by unfavorable weather conditions) is one of the most destructive injuries with which lettuce growers have to contend. It is not severe on the early spring crop nor on the late fall one, but during the summer it may destroy the salability of nearly every plant in the field. On affected lettuce, the edges of the leaves die and turn brown; in severe cases it interferes with growth.

In a general way tipburn is known to be caused by weather conditions, chief of which is high temperatures, but the exact combination of conditions is still being debated. Formerly, it was considered that the hot sun shining on the succulent, fast-growing tissue caused the injury, but tipburn can originate even in the dark. It is a degeneration of the cells due to faulty respiration, which is brought about by high temperature, high humidity, pro-

longed cloudy weather, and an abundance of soluble salts in the soil, especially nitrogen.

Control

No definite control measures are known. A few precautions may help to reduce the loss in a crop. Deep and frequent cultivations when the soil is packed by heavy rains, sparing use of potash and nitrogen, and medium applications of superphosphate have reduced the amount of tipburn in certain fields. The Big Boston head lettuce is very susceptible, and it might be possible to substitute some other variety for the midsummer crop. Some of the recommended Iceberg strains, such as 456, while not immune, have produced marketable crops.

YELLOWS

Lettuce yellows (caused by the Aster Yellows virus) is known also as *White Heart*, because the center leaves become bleached and dwarfed. The head does not form even though the plant may continue to live. Young infected plants usually die. Old plants are not much injured by infection. The same disease is found on many weeds and cultivated crops. It is carried only by the leafhoppers from one plant to another, and gradually is becoming one of the most important diseases of lettuce, endive, or escarole, asters, carrots, and other crops. It is especially serious on lettuce planted in midsummer.

Control

If all the weed hosts within 300 feet of the lettuce field are eradicated, the disease is reduced in severity. Weeds can be eradicated by growing cultivated crops adjoining the lettuce, or spraying the weeds on idle land with an eradicant to which a spreader has been added. The very young lettuce plants and the weeds about the crop should be sprayed regularly with DDT as recommended by entomologists for leafhopper control. The weeds can be sprayed throughout the season, but the lettuce should not be touched by any of the insecticide for at least thirty days before harvest. Only the midsummer crop requires protection. Linn, working on Staten Island, reduced the amount of yellows to one-fourth that in the check plots by growing the seedlings under cheesecloth. Late-grown lettuce should not be planted next to lettuce that will be harvested earlier, for at harvest time the virus-carrying insects migrate to the new crop.

MOSAIC

In mosaic (caused by a virus), the lettuce leaves become mottled with yellow and green, ruffled, or otherwise distorted and dwarfed. The whole plant has a sickly appearance, and usually will not bear a head. The virus is carried in the seed and is transmitted by aphids and other sucking insects.

If disease-free seed could be obtained, mosaic could readily be controlled, but until recently this was not found possible. In California some attempts have been made to produce mosaic-free seed by indexing, roguing, and isolations, so that a few pounds of Imperial 615 and Great Lakes were produced this year. Some varieties are less susceptible than others, but no really resistant strains are known in this country. Several are reported in England.

BIG VEIN

Big vein (caused by a virus) apparently was present a long time before it was recognized in California in 1934. Since then it has become an important trouble in several lettuce sections. In 1949 it suddenly became destructive on Long Island, and in 1950 did much damage in some upstate areas.

Infection may show at any stage of growth. Very young seedlings are killed outright. On older plants the first affected leaves have a pattern of pale-colored, interlaced, enlarged veins. Later

the plant is stunted and the leaves are crinkled and yellowed or sometimes with dead areas between the veins. No head is formed on early-infected plants. Even when the head forms, it usually is not marketable. In years favorable for the virus, the entire crop may be lost.

The disease is unique in that it is caused by a virus which lives in the soil and passes into the feeding roots with the water and other substances absorbed by the root hairs. The virus is transported in any manner that infested soil can be moved, especially on dirt clinging to the roots of seedlings shipped from State to State. It can also be carried in live roots of lettuce plants. So far as is known, it is not seedborne nor does it require insect vectors. It can remain alive in soil for at least eight years and cause new infections whenever soil temperature and moisture are favorable.

Judging from recent experiences, the disease may become epidemic in form when the winters are so mild that the ground is not frozen and the spring remains cool and wet until late. This permits the soil temperature to continue between 50° and 72° F., which is optimum for infection when coupled with much soil moisture. There is almost no disease when the soil is kept reasonably dry or when the temperatures rise much above 70° F. during the day. The virus is killed when the soil is heated to 149° F. for 30 minutes.

Control

After a field soil once becomes infested, it is difficult to combat the disease. Chemicals or heat ordinarily are too expensive to use under field conditions. In greenhouses or hotbeds, infection can be avoided either by retaining the day temperature at 75° F. or above and the night temperatures not much less than 60° F. If this is not feasible, the soil can be disinfested with steam, flash heat, or some chemical. Among those tried, ethylene dibromide and benzene hexachloride were not effective. Chloropicrin either alone or mixed with xylene, DD, Dowfume–N, and heat reduced infection satisfactorily. Formaldehyde was only partly effective, probably because it did not penetrate the treated soil deeply enough.

If the young plants are grown in relatively high temperatures, or in disinfested soil until they have grown beyond the usual stage for transplanting, they can be put into heavily infested fields without sustaining much loss. If the farm has too much soil contamination for early spring crops, the disease can be overcome by planting late enough to take advantage of high day temperatures. The disease disappears completely during midsummer and rarely is destructive in early autumn crops. It too is not present in epidemic form following a winter in which the soil freezes deeply and keeps the soil temperature about the roots low until the plants are partly grown.

Care should be taken in keeping the soil as dry as growth of the plant permits. During the critical spring period there should be no irrigation unless absolutely necessary, and then the water should be applied very sparingly.

There is some difference in varietal susceptibility but none of the Cos, Big Boston, nor Iceberg types proved resistant enough to grow safely where infection may be heavy.

DOWNY-MILDEW

Downy-mildew (caused by *Bremia lactucae*) is injurious mostly in the greenhouse or in coldframes when proper ventilation is not possible. The spots begin as lighter green areas on the upper surface of the leaves, and, as the lesions enlarge, the fungus fruits with white mycelial wefts in corresponding spots on the opposite side. The affected tissue later turns brown. The whole plant may be dwarfed and yellow. The fungus overwinters on wild lettuce and rarely on greenhouse lettuce. It requires a large amount of

moisture for growth as well as cold nights and relatively warm days.

Control

The control consists mostly in correcting conditions favorable for the fungus. In coldframes where the temperature often is rather low, the air must be kept comparatively dry or the mildew is sure to spread. In hotbeds and coldframes, special care should be taken to provide ventilation so that drops of moisture will not collect on the inner side of the glass and drip back on the plants, for such moisture provides an excellent environment for the growth of the fungus. The pitch of the sashes should be at least 4.5 inches, to reduce leakage, and the glass panes as large as possible, to permit enough light. The sashes should be well puttied and broken panes replaced. In greenhouses, if the night temperatures can be raised three or four degrees above normal for lettuce growing, the fungus will not thrive.

Wettable Spergon, 2 pounds in 100 gallons applied three times a week on the young upright plants, has been recommended elsewhere but has not yet been tried in New York State.

Some of the Iceberg strains are especially susceptible to mildew; therefore if this variety is grown, only resistant strains should be selected, particularly for fall crops or in the northern part of the State. The leaf lettuce Grand Rapids No. 1 is resistant, and considered by greenhouse growers as satisfactory in other ways.

GRAY MOLD-ROT

Gray mold-rot (caused by *Botrytis* sp.) is of little importance outdoors, but is destructive occasionally under glass. Rotted plants are covered with a dirty gray, fuzzy mold. The disease attacks weak plants mainly, and in some measure can be prevented by obtaining vigorous growth. The coldframes or hotbeds should be handled as suggested for the control of downy-mildew. In greenhouses, if the night temperatures are lowered as far as possible without injury to lettuce, the rot can be much reduced.

The disease sometimes is troublesome on the early crop grown outdoors, the infection coming from the seedling transplants that were grown in the greenhouse. Growing these seedlings in sterilized soil and keeping the humidity as low as possible helps to eliminate this source of the trouble. Dusting the seedlings at weekly intervals with Tersan diluted with an equal amount of talc gives remarkably good control of gray mold-rot if the temperature is above 58° F.

ONION

ONION MAGGOT

The onion maggot (*Hylemyia antiqua* Meigen) is sometimes destructive on the muck soils of New York. The adult of the maggot is an ash-gray fly about one-fifth inch in length and closely resembles the adults of the cabbage root-maggot and of the seed corn maggot.

The insect winters in the puparium stage in the soil of onion fields or under piles of onion refuse and cull onions that were discarded at harvest. In New York the flies begin to emerge about May 10 and continue to appear for about a month. Flies coming from refuse piles begin to emerge somewhat earlier than do those in the open field and emergence continues for a longer period. Not only are refuse piles dangerous centers of infestation because of the large number of flies that they produce but also because the period during which the flies emerge is materially lengthened.

The flies do not begin egg-laying as soon as they emerge but wait from one to three weeks before the first eggs are deposited. This is known as the *pre-ovi-*

position period and averages about ten days in length. The flies deposit their smooth, white, elongate eggs in crevices in the soil around the plant or in the avils of the leaves at the base of the plant. The eggs hatch in from two days to a week, depending on the temperature. The feeding habits of the maggots vary somewhat with the size of the plants attacked. The maggot requires from fifteen to twenty days to reach maturity. It then leaves the onion and burrows a short distance into the surrounding soil, where it transforms into a pupa within the hardened larval skin, or puparium. The puparium is chestnut brown in color and about one-fifth inch in length.

A second brood of flies emerges during July and early August, the greater number appearing during the last half of July. Usually a small partial third brood of flies appears late in the season. Sometimes newly hatched larvae of the last brood have just entered the bulbs at harvest time. These may develop in storage, causing serious loss.

Control

The most satisfactory and practical way to control the onion maggot is to spray with a 2 per cent lubricating-oil emulsion. For this purpose two types of oil, known as *red engine* and *lubricating oil*, have been extensively tested. The red engine oil is more widely used and on the whole is more satisfactory than the lighter paraffin oil.

Lubricating oils already emulsified and suitable for spraying onions can be purchased and are ready for use when diluted. For most growers these commercial emulsions are more satisfactory and economical than are the homemade preparations.

It has been the practice to dilute the stock emulsion with 8–8–10 bordeaux mixture, and this combination has given the most consistently satisfactory results. The oil emulsion can be used without the bordeaux, however, and good control obtained. The combination of the oil emulsion with bordeaux seems to increase the efficiency of the mixture somewhat; the bordeaux provides a stabilizer in case extremely hard water has to be used, and thus prevents a breaking down of the emulsion.

Some of the commercial emulsions found on the market contain about 66 per cent of oil, but other brands have a higher oil content. To obtain a 2 per cent emulsion, enough of the commercial stock emulsion should be used to supply 2 gallons of actual oil for each 100 gallons of the spray mixture. If a 66 per cent stock emulsion is used, 3 gallons of this emulsion are diluted with enough water to make 100 gallons. With stock emulsions of a higher oil content, a corresponding smaller amount is required.

For preparing the homemade emulsion, a large orchard sprayer is most convenient. The spray tank should be thoroughly cleaned of all spray deposits. Not more than 200 gallons of the emulsion can be prepared in a 30-gallon tank because of the foaming of the liquid. The materials

FIGURE 16. THE TRACTOR CULTIVATOR EQUIPPED WITH SPRAY ATTACHMENT FOR ONION-MAGGOT CONTROL

for each 100 gallons of stock emulsion are combined in the following proportion: 66 gallons of lubricating oil, 33 gallons of water, and from 50 to 100 pounds of potash fish-oil soap. The amount of soap required will vary greatly with the hardness of the water and the kind of lubricating oil used. Red engine oil is more difficult to emulsify than is paraffin oil and requires more soap. If the emulsion is to be applied merely diluted with water, it is important to have the emulsion stable, and an adequate quantity of soap should be used. If the emulsion is to be used in combination with bordeaux mixture, the minimum amount of soap indicated will usually be enough.

To make the emulsion, the proper amounts of the materials are placed in the spray tank, and the mixture is pumped back into itself through the spray gun for from 10 to 15 minutes. After this is finished, the emulsion can be transferred to storage containers through the spray gun, using enough pressure to break the liquid into a fine mist. For use, 3 gallons of this stock emulsion should be diluted with 97 gallons of either bordeaux mixture of water, preferably the former.

In spraying for the onion maggot, the object is to apply the spray in such a way that the soil immediately around the base of the young plants will be uniformly moistened by the emulsion. Applied in this way the oil kills the eggs and the young maggots as well as acting as a deterrent to the flies. To wet the soil uniformly, it is important that the spray be applied with a pressure of about 50 pounds.

Since the flies are active over a long period, several applications are necessary during the early part of the season to insure a satisfactory control of the insects. The first application should be made when the flies first appear in the field and begin to deposit eggs. This is usually when the young onions are about 1 inch high and when the first leaf pulls out of the ground and the plant begins to straighten up. Ordinarily three applications are needed at intervals of a week or ten days, and in some cases one or two additional sprays may be worth while. The first two sprays are indispensable, and the proper timing of these applications is of the utmost importance.

In plantings of less than an acre, the emulsion may be applied with a hand sprayer. For larger areas, the most convenient way to apply the spray is with a small garden tractor equipped with a special spray attachment. A low-gallonage low-pressure type of sprayer as described on page 00 has also been found practical to apply the sprays.

Although timely and careful spraying is the most important operation in onion-maggot control, other measures should not be overlooked. Piles of cull onions around packing sheds and along the edges of fields serve as breeding centers for the onion-maggot flies, and they should be disposed of by burying, burning, or hauling away to a considerable distance from any land to be planted to onions the following year.

ONION THRIPS

Onions are subject to injury by a small yellowish or brownish thrips (*Thrips tabaci* Lindeman) which puncture the epidermis of the leaves, suck out the juices, and cause the plants to turn whitish, wilt, and fall down. While the insects cause important losses in all parts of the State, they are more destructive seemingly in muck areas than elsewhere. Onions grown from seed are more severely injured by the thrips than are those grown from sets, but the latter are usually heavily infested and serve as breeding reservoirs from which the insects spread to seed onions.

The onion thrips pass the winter in both the adult and the nymphal stages on onion plants left in the field and in rubbish banks and along the edge of the fields. The female inserts her minute whitish eggs into the tissue of the leaf. The eggs

hatch in from a week to ten days. The nymph passes through two stages while feeding on the plants and then enters the ground, where it passes through two more immature stages before becoming adult. The life cycle is completed in about twenty-six days. There are five or six generations annually, and breeding is continuous until stopped by cold weather. With the favorable conditions of dry weather during July and August, the thrips population may increase so that from 200 to 500 thrips may be counted on a single onion plant. This degree of infestation causes commercial injury. Evidence indicates that when plants show an average of ten thrips per plant insecticidal control should be started. Indeed, in the Prattsburg muck area, onion growers practise thrips and disease control regularly, making from four to six spray or dust treatments of DDT and dithane each season, and they are always well pleased with their control results.

Control

Dusts containing ¾ of 1 per cent rotenone have proved satisfactory for use on bunching onions where fresh green tops bring a market preference. These dusts are most effective when used at weekly intervals as the thrips appear on the plants. They must be applied thoroughly.

On large muck areas in the Hudson Valley and up-state, DDT and parathion have been used extensively to control the onion thrips. As dusts, a 5 per cent DDT or 1 per cent parathion have been found effective. DDT has also given fair to good control when used as a solution in an oil concentrate and applied in low gallonage by aircraft, but good coverage was necessary. The same is true of a DDT emulsion and an emulsion of parathion when used in a low-gallonage low-pressure sprayer.

The insecticide Aldrin is also effective in controlling thrips. It is used as a 2 per cent dust at the rate of about 35 pounds per acre. It may be used also as a spray at the rate of about 1 quart of a 25 per cent emulsifiable concentrate per acre, or as a wettable powder containing 25 per cent of Aldrin at the rate of 2 pounds per acre.

The time to begin insecticide treatments seems to be important. This is often early in the season or about June 15 when the injury first appears. It appears advisable for a grower to make two applications at an interval of from five to seven days beginning when a field has an average population of about ten thrips per plant. If control treatments or weather conditions do not check the infestation, two or three more applications should be made.

SMUT

Onion smut (caused by *Urocystis cepulae)* is rather common in New York State on the older muck areas. It is not present in the Southern States where the temperatures are high.

The presence of smut is first indicated by one or more dark spots at different heights in the leaves of the seedlings. These are more or less opaque when the plant is held up to the light. After a time, usually while the second leaf is developing, longitudinal cracks begin to appear on one side of these spots. These crevices widen and show within a dry fibrous mass which is covered by a black, sooty powder, made up wholly of the ripened spores of the fungus. These spores are blown or washed into the ground. Similar smut lesions may show in the second leaf and in those formed subsequently. Plants thus diseased usually die early, especially if the soil is dry. Some may make considerable growth and survive even up to the time of harvesting. In such specimens the smut shows itself by black elevations upon the bulb, running down to the very base and extending upward into the leaves.

The cause of onion smut is a fungous parasite that lives from year to year in the soil. Instances are known in which onions planted in a smut-infested field after an interval of twenty-seven years became

severely affected by this disease. Only onions grown from seed are subject to this disease and these are not attacked by the parasite except in the very young stages. Onions grown from sets or transplanted from soil free from the organism are not subject to the smut. Sets grown on smut-infested soil, however, can transmit the fungus to new fields. The spread of the disease from State to State is mostly by means of these infected sets, and locally by washing streams or in any other way that infested soil can be carried from one field to another.

Control

Because the fungus persists for such a long interval in the soil, crop rotation is of little value in reducing the amount of smut in a field. Since onions can be attacked only in the seedling stage, the disease can be controlled by planting healthy sets, by seed treatment, or by sterilization of the soil with formaldehyde in the immediate vicinity of the germinating seed and seedling plants.

Seed Treatment

The seed is first moistened with a sticker solution made of 50 grams of methyl cellulose (Methocel 15) dissolved in 1000 cubic centimeters of lukewarm water. This is a scant 2 ounces in a quart of water. While exactly ¾ pint of this solution are being poured over 4 pounds of seed, the sticker and seed are stirred vigorously for 1 or 2 minutes. Four pounds of Tersan are then added, and the seed is placed into a mixing shaker or pelleting machine where it is shaken for 4 or 5 minutes. A paint-conditioning machine has been used successfully for this purpose. A custom treating service has been conducted in the counties where onions are grown intensively, and affords an easy, reasonably cheap way to have the treating done correctly.

If smut is known to be only mildly destructive, 3 or 4 pounds of dry seed can be treated with 1 pound of Arasan and sown immediately. This amount of fungicide is not effective where there is a heavy smut infestation.

Formaldehyde

Formaldehyde solution is poured into the furrow with the seed from a tank mounted on the handles of the drill. It is important to apply 1½ gallons of formaldehyde to the acre if rows are 14 inches apart, but, to prevent seed injury, the formaldehyde must be diluted with water as follows:

Formula and solution strength	Rate per acre	Feet row per gallon	Approximate time of flow per gallon
	Gallons	*Gallons*	*Feet*	*Seconds*
1. 1 in 65	100	375	90
2. 1 in 75	115	322	78
3. 1 in 100	150	280	67

When muck is so wet that it nearly sticks to the wheel of the drill, the first formula should be used. On muck that has been fluffed up and has become partially dried on top, the last formula is best. Usually the second formula has given excellent results.

The rate of the flow can be governed and tested in advance by inserting a union somewhere in the delivery tube below the solution tank. In the union are inserted lead, rubber, or leather discs that have holes of various sizes (less than $^{5}/_{16}$ of an inch).

As the operator starts to push the drill, he opens the stopcock which starts the solution flowing into the furrow an inch behind the seed. Barrels of solution are placed at the ends of the field. To get the most even flow or distribution of solution, whether the tank be full or nearly empty, it should be equipped with an air-tight cap. Air is then admitted through a small tube attached at the bottom of the tank, not the top.

Occasionally disappointing results have

been obtained with the liquid-formaldehyde method. In nearly every instance investigated, the reason was due to the use of insufficient formaldehyde per acre, insufficient solution per foot of row to soak all the soil above the seed, heavy rains too soon after treatment, or occasionally too heavy winds which caused drifting of the muck.

DOWNY-MILDEW

Onion mildew (caused by *Peronospora destructor*) is common in the State, and during wet, cool weather may become most destructive.

It seldom occurs early in the growing period of the plant, except on perennial or winter onions when it may develop any time between April and October. The first commercial onions to show symptoms are the early crops grown from sets which may be attacked early in June. Infection first shows as a dull, pale, green spot usually near the tip of a leaf. Then during the night and early morning when dew is abundant the fungus forms a pale purplish mold over the surface of the lesion. The spores borne on this lesion are blown to other leaves for new infections. The old lesions so weaken the leaves that they often collapse at those points, later turning olive green to almost black with secondary molds.

The pathogen in New York overwinters chiefly as vegetative mycelium in perennial topset, or winter, onions. It grows up into the tissues of the new leaves early in the spring and sporulates on them abundantly by the time the commercial crops are planted. In Europe it has been found also to pass the winter in some varieties of commercial bulbs, and as oospores formed in diseased foliage. But these methods seem to be less important in New York than the one involving winter onions. Viable spores have been trapped 1500 feet above a diseased onion field in July in central New York, so undoubtedly they are wind-borne.

The parasite, being a downy-mildew, requires plenty of moisture with rather cool nights and relatively warm days. When such a combination of weather occurs, an epidemic may soon be expected wherever the fungus is present.

Control

One of the chief sources of inoculum are the numerous beds of winter onions, which are present in many home gardens. If all such beds near commercial plantings of onions could be removed, much of the danger from the mildew might be prevented. During the past fifteen years, the removal of many dozens of these diseased plantings within a half mile or so of muckland onions has gradually delayed the onset of field innfections and hence the severity of the losses. It is believed that elimination of these nearby sources of primary inoculum has actually reduced the frequency of heavy mildew seasons from 1 in 3 years to 1 in 9 years. The other recommendation is to refrain from growing early set onions in the same district with late-seeded onions because the early crop is likely to be infected by the mildew and pass it on to the late crop sooner than it would otherwise contract it.

Sometimes it is possible to select varieties that have small tops, which dry quickly and do not mildew so severely as do those with large tops. As an instance of this, the small-topped Mountain Globe Danvers do not blight so badly as do the large-topped South Port Yellows.

Spraying onions to control mildew is receiving considerable attention now that there is good insecticide for thrips control. The materials most likely to give satisfaction seem to be liquid Dithane or Parzate, 2 quarts plus ¾ pound of zinc sulfate in each 100 gallons. From six to ten applications should be made at 6- to 8-day intervals beginning in mid-June. Much of the benefit from spraying is due to the control of blast and Alternaria blights. Dusting and aeroplane applica-

tions have not proved so effective as have the sprays.

NECK-ROT

Neck-rot (caused by *Botrytis allii* and others) is known to be serious on mature onions and on sets, and probably is present in every part of the world where onions are stored. In poor storage places the loss may comprise the total crop. In some years the fungus also blasts the onion flowers or injures the viability of the seed.

Neck-rot is confined to varieties of the common onion. The white onion is much more susceptible than is either the yellow or the red type. The onion with a thin neck, which dries easily, is less susceptible than is another of the same variety that is thick-necked.

The disease seldom occurs on the bulbs while they are in the ground, although the fungus may attack injured leaves even when the plants are young. The lesions, which finally may involve the whole bulb, appear first as sunken dried out places about the neck. In a cross-section the scales appear as if they had been cooked. The tissue is soft and of a brownish color. Between the scales is a gray mass of mycelium, and on the dried parts of the scales small black sclerotia begin to form. On the outside, particularly about the neck, the sclerotia may form in a solid crust. Onions that do not have superficial sclerotia often have part of their surface covered with the characteristic ashen-gray fruit-layer of the parasite. The roots may be included also in the decayed area, especially if the bulb is attacked at its base. Occasionally, soft-rot bacteria follow the neck-rot, and cause the onion to become soft, watery, and foul smelling. The neck-rot, when unaccompanied, results in a dry-rot.

Infection takes place through wounds at the neck of the bulbs during or following harvest, the invaded area continuing to enlarge while the onions are curing and after they are housed. The fungus seldom passes from bulb to bulb in storage unless the adjoining tissue is exposed by open wounds.

The Botrytis survives the winter by means of the sclerotia and as mycelium in the decaying host. The spores are blown by wind or carried on tools and clothing to the flower head, the leaf sheaths, the inner dry scales, and at harvest time to the cut tops and roots.

Control

If the fact is kept in mind that well-dried, well-stored onions are seldom affected, protection will seem fairly simple. First, the onions should be so grown that they will mature readily. Late applications of fertilizers and the presence of downy mildew, weeds, and wind barriers should be avoided. At harvest the tops should be cut fairly close, and every attempt made to dry the stubs before placing the crop in storage. It has been shown that mature bulbs or sets may be dried artificially to good advantage. They are placed in shallow trays and held at 90° to 120° F. for forty-eight to seventy-two hours. In addition, all thick-necked bulbs, or scallions, are removed as their slow drying qualities cause them to succumb quickly to the disease.

The onions should be stored in slatted crates, which are so piled that air can circulate all about them. The temperature should be kept as nearly 32° F. as possible, and the humidity of the air as low as the arrangement of the room will permit. A steeply pitched roof with ventilators at the peak will aid in removing the warm moist air. If the doors are then kept tightly closed on damp misty days and opened only when the air is cool and dry, the amount of shrinkage from rot in an onion crop can be much reduced.

ONION BLOAT, OR BULB NEMATODE DISEASE

In three counties where onions have been grown continuously for many years,

losses have been serious recently from a microscopic nematode or eelworm (caused by *Ditylenchus dipsaci)* in the soil which can attack all stages of the onion from the youngest seedling to a nearly mature bulb. Young plants become stunted and pale and often their stems and the lower portions of their leaves swell or become twisted, wrinkled, or otherwise malformed. Later in the season infested areas in a field of set onions can be detected by much wilted and yellowish foliage and missing plants. The nemas living between the cells within the plant greatly weaken the leaves, and in young bulbs produce a mealy or frost-like consistency that paves the way for secondary soft-rotting bacteria and fungi. Infected bulbs seldom keep well if they reach harvestable size. Such bulbs are light weight and, though slightly swollen, are often punky in texture.

The bulb nematode can readily attack other crops in the onion family, including garlic, leek, and chive, but probably a distinct strain affects Easter and Royal lily, narcissus or daffodil, hyacinth, and iris. Certain strains have been found also on a wide variety of other host plants including alfalfa, bull thistle, several clovers, dandelion, hawksbeard, oats, peony, potato, phlox, plantain, primrose, rye, strawberry, Sweet William, and teasel.

This nematode is much worse in wet seasons and in regions where humidity and rainfall are high or when irrigation is practiced, because it becomes active in water and lies dormant in dry soil. It is, therefore, to be feared during a series of wet summers.

The chief means of overwintering in onion fields are diseased bulbs and plant parts left in the field after harvest. If a very thorough and complete clean up is practiced at this time, the spread of the disease is checked. Eradication cannot be expected unless this clean up is combined with either fallowing or rotation with resistant crops such as carrots, corn, lettuce, spinach, asparagus, tomato, potatoes, beets, and broccoli, although beets and broccoli have been named as an occasional host. The practice of growing a cover crop of rye after harvest should be discouraged on infested land as this can support the onion strain of this nematode.

The growing of potatoes and some other nonsusceptible crops for a period of two to four years between onion crops is recommended as the best way to eradicate this disease.

Great care should be exercised to prevent land on which sets are grown from becoming infested because diseased sets can carry the nematode to healthy fields. This means one should never save bulbs from a field where the disease occurs, and set them out on upland where sets are to be grown later.

A very hot, dry August is believed to reduce greatly the number of nemas that can survive till the following season, while a cool, moist summer is sure to be followed by an increased amount of disease the following season.

Chemical treatment of small areas may be resorted to in certain fields before the disease has spread, but is too expensive for general practice, and is still in the experimental stages.

The nematode may be carried in the seed of oats, onion, and the legumes under certain conditions. Since good onion seed will stand a 25-minute soak in water at 125° F., it is likely that such a treatment could be successfully employed if seed were known to be infested.

PARSNIP

CANKER

The unsightly chocolate brown discoloration on the white parsnip roots, and caused by the fungus *Itersonilia sp.*, greatly reduces the salability of this vegetable. The browning is most commonly near the shoulder or crown of the root but may also be present on the sides and downward almost to the tip. Dr. R. E. Wilkinson and

Grover Sowell, Jr. found that the same fungus causes parsnip leaf spot. They worked out enough of the life history to make recommendations regarding its control.

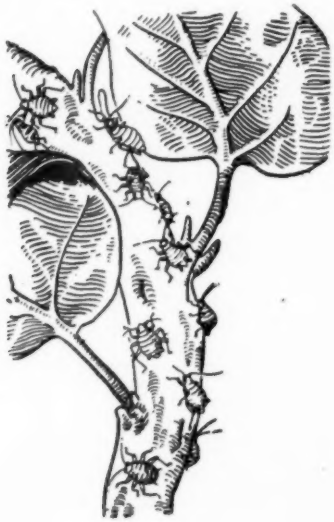
They found that the disease was most prevalent in a cool wet season or in low areas of the field. Their control suggestions, therefore, are to plant parsnips only in well-drained soil, to practice crop rotations, to eradicate wild parsnips, to hill the soil gradually in a ridge over the crowns, and in cool damp seasons to make regular spray or dust applications. Copper, in this instance, is the preferred fungicide. Weekly to 10-day applications of bordeaux mixture 4–2–50 or a low soluble copper suspension, 2 pounds of metallic copper in each 50 gallons, are recommended. The exact time to begin spraying is still unsettled, but the critical time for root infection seems to be the period beginning with August 1. Possibly the spraying should be started slightly before that date, and at least five applications made at 10-day intervals. Still more applications might be profitable during continued wet weather.

PEAS

PEA APHID

The pea aphid (*Macrosiphum pisi* Kaltenbach) is a most destructive insect in some seasons. It is sensitive to weather conditions, and a year of great abundance may be followed by five to eight seasons in which it does not need to be controlled on cannery peas grown up-state. When abundant in up-state New York, it has been known to ruin completely a crop in a few days as the aphids develop and feed upon the flower spikes and growing pods in great numbers. Under Long Island conditions, a very light infestation of two to four aphids per young plant of picking peas has been known to transmit the mosaic disease which prevented the setting of a crop.

FIGURE 17. APHIDS FEEDING ON PLANT STEM



The pea aphid is a rather large pea-green plant louse that harmonizes well in color with the plants on which it may be found. In addition to peas and sweet peas, it attacks clover, vetch, alfalfa, and sweet clover. Under New York conditions, except on Long Island, the pea aphid usually passes the winter in the egg stage on one of these plants. In the spring the first generations of the lice are produced on the winter host plants — clovers and alfalfa. After the first generation, some of the lice are winged and migrate to other plants where feeding conditions are more favorable. Some of these migrating lice find their way to the peavines, and there start colonies. Reproduction is rapid, and soon the stems become covered with the lice. The leaves, the blossoms, and the pods are soon attacked. Infested leaves become slightly thickened and curled; in-

fested blossoms are blasted; and injured pods are stunted, deformed, and rendered worthless. Badly infested plants take on a sickly yellowish appearance and may be killed outright; thus the yield per acre may often be cut severely.

Control

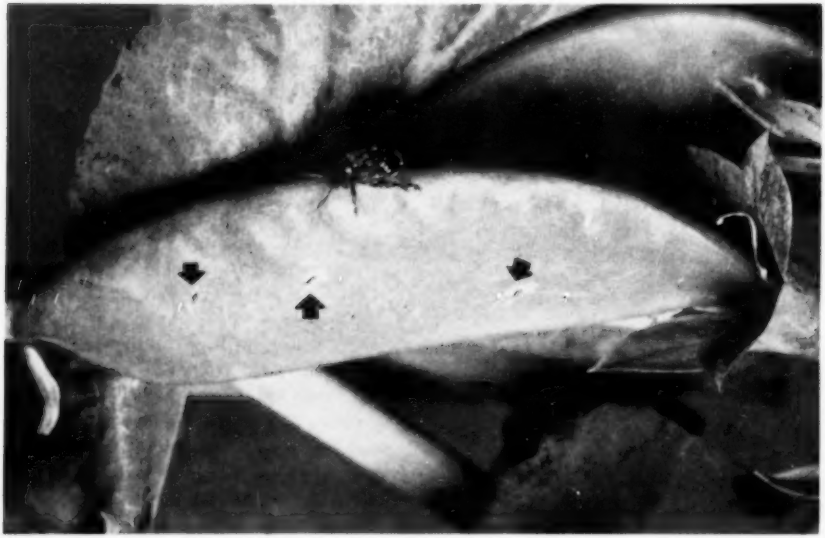
On cannery peas the control of the pea aphid is usually directed if not indeed carried out by the canners. On picking peas, control is the responsibility of the grower.

Control treatments are justified on cannery and picking peas when ten sweeps of a standard 12-inch insect net yields from 300 to 1000 aphids at a time when the plants are from 6 to 12 inches high. Where mosaic disease is a problem, as on Long Island, control must be practised when only two to four aphids are on a plant on the average.

A 1 per cent rotenone dust, or a 3 per cent DDT dust, or a 1 per cent parathion dust, or a 5 per cent malathon dust, or a 1 per cent TEPP dust has been found effective against the pea aphid. Effective sprays are 4 pounds of a 4 or 5 per cent rotenone powder, or 2 pounds of 50 per cent wettable powder of DDT, or 1 quart of 25 per cent emulsion of DDT, or 1 pound of 15 per cent wettable powder of parathion, — each in 100 gallons of water. Other effective sprays are parathion, TEPP, or malathon emulsions. Nicotine sprays and dusts have also given good control under favorable weather conditions.

Equally as important as the insecticide to be used for efficient control is its distribution. Dusts need to be applied at the rate of 25 to 35 pounds and sprays at the rate of 100 to 125 gallons per acre. Low-gallonage sprayers may probably be used to apply concentrate sprays effectively if the coverage is uniform. Aircraft treatments with suitable insecticides have been found satisfactory only when the coverage is good.

FIGURE 18. ADULT PEA-WEEVIL
Eggs are indicated by arrows



Insecticide Residues on Peas

DDT should probably not be used within twenty-one days of harvest or on peavines to be used as silage for feeding to milk cows. Parathion when used in excessive quantities may also show an objectionable residue if used within ten days of harvest. A substitute for these insecticides would be rotenone, or a TEPP spray, or a TEPP dust used at manufacturer's directions.

PEA WEEVIL

The pea weevil *(Bruchus pisorum* Linn.) is a snout beetle about $^1/_5$ inch long, brownish in color, mottled with gray, white, and dark brown. Another characteristic of its appearance is its wing covers which do not extend to the tip of the abdomen.

The weevils pass the winter hiding under trash or under loose bark of trees. They have been found also in the cracks of fence posts adjacent to a field in which peas were grown during the previous season. They appear on peas in up-state New York when the first pods are evident, and lay their eggs on them. As many as 15 to 20 eggs may be glued onto a single pod.

The larva or grub stage enters the pod just as it emerges from the egg, finds a pea, and feeds and grows inside it. A brownish dot marks the point on the pod where the newly hatched grub has entered. The so-called wormy peas are objectionable to the trade when found in frozen or canned packs and indeed they may be declared as unfit for human consumption. The insect pupates within the pea and emerges from it as a weevil in August. Large numbers of weevils may develop in scattered peas left on the ground at harvest.

Control

Plowing of the soil by the first of August helps to reduce an infestation of the following year. This cultural practice prevents emergence of the adult weevils.

Canners must sometimes resort to control with insecticides. Either a 1 per cent rotenone dust containing preferably 2 per cent of lubricating oil, or 1 per cent parathion, or of 5 per cent of malathon dust is effective. Sprays of rotenone or parathion have not been used on a field-control scale.

Several applications may be necessary at from 4- to 6-day intervals if it is desired to keep an infestation down to an absolute minimum. The first is made when net sweeps reveal one weevil in about 50 sweeps made in each of several parts of a field. This may be when the peas first show blooms. Further treatments are necessary as later sweeping of the peas produce weevils that have just entered the fields from their overwintering places. The weevils may continue to enter the fields over a period of two to three weeks.

Aircraft were used with success somewhat extensively in up-state New York to control the pea weevil with insecticides during the spring of 1949 and 1950. At that time some fields required from one to three treatments to control the insect to the point where the infestation was negligible in a finished processed product.

BLIGHT

Really three blight diseases (caused by *Ascochyta* and *Mycosphaerella)* attack the pea, but as the organisms causing them are so nearly alike, they are treated here as one. The disease produces black to purplish streaks on the stem. The lesions are more pronounced at the nodes, where they enlarge into brown or purplish irregular areas and may extend as high as 10 inches above the roots. The leaves become spotted in various ways. Sometimes the spots are small purplish irregular dots, while at other times they are fairly large, almost circular, and may have concentric circles in them. On very susceptible varieties, the whole leaf may shrivel and dry. The spots on the pods are similar to those on the leaves, except that on the fleshy pods they are sunken and do not have concentric rings. When the dis-

ease is severe, the plant may not emerge from the ground or, if it does push through the soil, it may be killed soon after. Older plants do not succumb to the disease but their yield is much reduced.

The pea blight is caused by three fungi, the life histories of which are almost alike. They are carried in the seed, and cause infection when the plant is emerging. Rains splash the spores to neighboring plants until a whole field is infected. The diseased seed and the pea straw serve as places where the fungi may survive until the following season.

The optimum temperature for growth of the fungi is approximately from 75° to 80° F. A fairly rainy season is required for much dissemination of the disease.

Control

The general directions given for the control of pea wilt (page 75) apply equally well to blight. Well-drained soil, plowing under deeply in the fall all diseased refuse, and long rotations particularly are needed to control blight. But the most important measure of all is to procure healthy seed. It is strongly recommended that seed be brought from the Far West where irrigation or dry-land farming does not permit the growth of the pathogens. If this is impossible and the source of the pea seed is not known, it is well to have the specialist at the state experiment station test the seed both for germination and percentage of disease. A small cost is attached to this testing. The grower can obtain the details of the plan by applying to his county agricultural agent.

Seed treatment has not proved successful.

WILT, NEAR WILT, AND ROOT-ROT

Wilt (caused by *Fusarium* spp.) is not so common in New York as it is in some of the mid-western States, but it may cause much loss in individual fields. Near wilt, on the other hand, may be common and destructive.

Affected plants may be dwarfed in size, and have small leaflets rolled and distorted. Distinct wilting may or may not occur. The dwarfing, loss of color in the foliage, and browning of the water ducts in the stem are symptoms that are considered constant for the disease. No conspicuous lesions are present as is true of the various root-rot troubles.

In root-rot the fungus may enter the base of the stem above the cotyledons and destroy the tissues until the tap-root is rotted away from the stem. This lesion usually is reddish brown and wedge shaped. Yellowed or dead plants may occur singly scattered through the field or in small patches. These diseased plants often stand out conspicuously because of their yellow color or dried upright foliage. In high soil temperatures, the rot may not progress so rapidly; but the water ducts in the stem turn brown and the plant wilts. Under favorable growing conditions, new roots may appear above the lesion and permit the development of at least some pods.

The fungi have been found in the seed to a very slight extent. This apparently accounts for the spread of the diseases over wide distances. They are disseminated locally with infected pea straw, in contaminated soil, and in running water. The organisms spread slowly within a field, but after gaining entrance can remain alive a long time. If infected peavines are perfectly ensilaged, the fungi are killed; but when the vines are placed in a stack, most of those on the outside do not undergo fermentation and therefore serve as a source of inoculum when hauled to the field for manurial purposes.

Increase in soil moisture will accelerate the growth of the wilt Fusarium, but the most important environmental factor is the soil temperature. It does not grow at soil temperatures lower than 47° or higher than 85° F. and has for its optimum 70° to 72° F.

Control

Only general control measures are known. It is advisable to select well-drained soil that has not grown peas for at least four years. Contaminated pea straw should not be placed on fields where peas are expected to be grown. Burning pea straw in the fall is a questionable practice, for it is wasting much good green manure, and is not eliminating stubble that may have most of the inoculum. Since temperature is important, the earlier the peas are planted, the less chance the soil has of becoming warm enough to favor infection until the plants are too large to be much injured.

If soil selected is low in humus, the growth of the plant can be hastened and the consequent injury from root-rot lessened by applying fairly heavy applications of commercial fertilizers.

In late years much work has been done on breeding pea varieties resistant to wilt. There now are satisfactory resistant varieties which the canners usually grow and which constantly are being improved. No pea varieties are distinctly resistant to the root-rot. Recently a midseason, wrinkled pea, named *Delwiche Commando,* has been listed as being almost immune to near wilt.

ROOT-ROTS

Pea root-rot (caused by *Aphanomyces euteiches, Pythium ultimum, Rhizoctonia,* and others) is a serious trouble in many sections where the crop is grown extensively. The various centers of infection are scattered throughout the field and gradually enlarge as the season advances. The disease causes a rotting of the roots and the parts of stem that are below the surface of the ground. The diseased roots first appear water-soaked, then become soft and light brown or yellowish in color. Finally the outer layers of host tissue decay and slough off, leaving only the slender central core. If one of the affected plants is pulled up from soft soil, the central core of the taproot and some of the larger side roots will pull out as a long string. This peculiarity, together with the color of the lesion, helps to differentiate the root-rot from the wilt and from Rhizoctonia rot. Plants affected while still in the seedling stage usually lose their healthy color, slowly shrivel, and die. If the plants are half grown or more when infection occurs and conditions are good for pea growth, there may be no symptoms of the trouble aboveground. The plants may continue to grow normally and produce a crop.

Rhizoctonia is so common everywhere and affects so many plants that it is not surprising that under certain conditions it may cause serious trouble on peas. It affects mostly the base of the stem, where it causes a depressed reddish brown lesion that may or may not girdle the plant. It can be differentiated from the Fusarium root-rot in not producng a black or wedge-shaped lesion, and from the common root-rot by not leaving the central core of the root, which can be pulled out like a long string. Rhizoctonia is common on many hosts but probably only certain strains affect the pea. These overwinter in the soil and in crop refuse.

The other root-rots are caused by several of the lower groups of fungi. If a diseased root is crushed and the tissue is placed under the microscope, hundreds of resting spores may be found. It is in this form that the fungus overwinters. In the spring these spores germinate either by a long fungous thread or by small spores that can swim about in the soil water. These, together with the summer spores, are extensively abundant and can be carried by running water in the soil that is moved by splashing rain, and with diseased plant refuse. So far as is known, the fungus is never disseminated with the seed. When conditions are favorable and peas are grown successively on the same soil, or in short rotation, the pathogen grows luxuriantly.

The conditions most favorable for the root-rot are: type of soil that hold the water readily, as stiff clay, or sandy soil underlaid with hardpan; plenty of rainfall; and fairly high temperatures.

Control

The general control measures are the same as those suggested for the Fusarium root-rot (page 75). In the long rotations, however, it must be kept in mind that the fungus can attack also vetch, alfalfa, sweet clover, and to some extent tomatoes, barley, and oats. The rotations should consist of such crops as corn, cabbage, timothy, and members of the onion family.

Early planting in well-drained soil is especially important in the control of root-rot, for if the plants can be grown to half their normal size before infection takes place, the crop will continue to develop. In many parts of the State the soil is much cooler and the possibility of rainfall is less during April than during May, June, and July.

No resistant varieties have been found, so that if the root-rot once becomes generally distributed over a farm, it would be well to grow other crops for a few years. Seed treatment with Spergon or Arasan as suggested for the control of damping-off (page 99) also helps somewhat in retarding root-rot infection.

PEPPER

Several kinds of aphids and the pepper maggot are sometimes destructive to pepper plants and their fruits. Aphids suck the sap from the lower surface of the leaves. When twenty or more are observed on the average beneath a leaf, injury is being inflicted. The pepper maggot causes the fruit to be unfit for human consumption.

APHIDS

The aphids usually appear in injurious numbers in a dry and warm period. Continued feeding causes the foliage to wilt. At times some of the plants die. The aphids can be controlled by sprays or dusts as described on page 29 for the control of the cabbage aphid.

PEPPER MAGGOT

The maggot is the immature stage of one of the fruit flies (*Zonosemata electa* Say). The fly is somewhat larger than the house fly. Usually, it is light yellow in color and its wings are marked with distinctive smoky black areas. The flies are active mostly early and late in the day, and are likely to hide from sunlight.

The flies can be seen among the dense foliage of pepper plants about the time when the oldest fruits are approximately one-third grown and when the plant may be only about 9 inches high. In 1950 they emerged in the Capitol area of the State from July 8 to 18. This was determined by observing their daily appearance in screen wire cages placed over peppers that were infested with maggots in the fall of 1949.[2] A grower must time his insecticidal treatments fairly accurately and must "cage" infested peppers each fall to determine the emergence dates.

Soon after emergence the flies begin to lay eggs in the young pepper fruits. The egg puncture is a tiny blackish spot or dimple. The slender somewhat pointed yellowish egg usually protrudes through the skin and can be seen from the inside. The eggs hatch in a few days to produce maggots. The feeding of these growing maggots within the pulp and among the seeds renders the pepper unsaleable.

For some years, the pepper maggot has been known to be seriously destructive at times on Long Island. In recent years it

[2]These observations were made by Schenectady County Agricultural Agent Walter Durniak who conducted some of the field tests upon which the control suggestions are made.

has been increasingly destructive in Schenectady and Albany market garden areas and possibly also in the Hudson Valley.

Control

Until more is known regarding the performance of some of the newer innsecticides tested, a grower should probably plan to make two dust treatments (or their equivalent in sprays) at a five-day interval, although one properly timed application may give commercial control. A 1 per cent parathion dust is suggested at the rate of 40 pounds per acre. As a spray one could use 1 pound of 15 per cent wettable powder in 100 gallons of water at the rate of 115 gallons per acre.

Analyses made of the pepper fruits exposed at the time of treatments for parathion residues at Cornell University showed five days after the last treatment 0.33 to 0.59 part per million, whereas twenty days after the treatment they showed 0.02 to 0.03 part per million. This was prior to the first commercial picking.

SPINACH

SPINACH APHID

One of the sometimes serious pests of spinach is an aphid known as the green peach aphid *(Myzus persicae* Sulzer). It may appear in great numbers just before harvest in fall, and the infested spinach may be refused by the buyer. This species of aphid feeds upon a wide variety of vegetable crops and weeds.

Control

This aphid can be controlled with a dust containing a 3 per cent nicotine, or 1 per cent rotenone, or 1 per cent parathion, or 1 per cent TEPP freshly made. The equivalent in sprays can be substituted for the dusts as described for the control of the pea aphid on page 72. The parathion should not be used within fifteen days of harvest.

It is important in controlling the spinach aphid to begin when the infestation is present in small numbers because a heavy infestation is likely to require two treatments to get commercial control. Early treatments are necessary if the infested spinach is to be processed and complete freedom of aphids is required.

In some seasons the aphids are found in numbers on the spinach as it is being cut for fresh-market consumption. A dipping or an emersing of the cut plants in a pyrethrum spray solution causes the aphids to loosen their hold. An immediate washing treatment then removes them. The dipping solution should be a synthetic spray concentrate containing 1 or 2 per cent of pyrethrum extract diluted with from 600 to 800 parts of water. This treatment may need to be followed by washing.

There are also so-called insect loosener concentrates on the market which are diluted with from 3000 to 5000 parts of water to make a wash, that causes the aphids to loosen their hold when the plants are run through the wash. They have been used with some success to free cut spinach plants from aphids just before packaging.

SPINACH LEAF-MINER

The leaves of spinach, beets, and chard are subject to infestation by a white or yellowish maggot *(Pegomyia hyoscyami* Panzer) that mines in the tissues between the two outer layers, producing an irregular blotch. Several maggots are usually found in the same leaf, and often the blotches coalesce. The flies of the spinach maggot appear in the field in April or May. The female fly deposits her white, elongate eggs singly or in rows of two to five, side by side, on the underside of the leaves. The eggs hatch in from four to

six days, and the young maggot works its way into the tissue of the leaf and starts to excavate its mine. The maggot becomes full-grown in a week to sixteen days. It then deserts the leaf and enters the ground, where at a depth of from 2 to 3 inches it transforms to a puparium. From two or three weeks later the flies emerge and soon lay eggs for another brood of maggots. There are three generations a year and a partial fourth.

The spinach maggot is most troublesome when attacking spinach, chard, and beets that are to be used for greens. It is especially objectionable in spinach grown for canning.

Control

Little is known regarding the control of the spinach leaf-miner when its maggot stage is found mining the foliage of leafy vegetables that are to be used or marketed as fresh greens. Tests conducted on related leaf-mining insects indicate that a parathion spray prepared by mixing 1 pound of 15 per cent wettable powder in 100 gallons of water gives a high kill of the miners when they are very small or just after they have hatched from the egg stage. Equally as important as the spray is the timing of the treatment. The foliage of a crop of beets, spinach, or chard would need to be examined with some regularity to find when the small mines are first evident. A treatment should then be made followed by a second treatment a week later. Two treatments should protect a crop such as spinach and beets to be harvested as greens. From 1 pint to 1 quart of a 15 or 25 per cent parathion emulsion in 100 gallons of water might be used as a substitute, as might a TEPP spray at manufacturer's directions.

Thorough wetting of the plants with the spray is necessary, and the pressure should probably be at 300 pounds or more. The parathion should not be applied within fifteen days of harvest. The TEPP could be applied within a day or two of harvest.

When the mine blotches are readily observed because of their size and foliage discoloration, it is probably too late to correct an infestation with an insecticide. Immediate removal by plowing the unharvested parts of a crop probably lessen a possible infestation in a crop to be grown later in the season. The destruction of the remnants of a crop would prevent the maggots in it from producing a later brood of flies.

DOWNY-MILDEW, OR BLUE MOLD

The downy-mildew, or leaf-mold, (caused by *Peronospora spinaciae)* is prevalent wherever spinach is grown. It may be absent during certain seasons and then later destroy whole fields or, by appearing year after year, it may constantly menace the spinach crop. It apparently affects no weeds or other crop.

The disease on the leaves is manifested by variously sized pale-yellow spots. On the lower side the lesion is covered with a gray to violet-gray mold. The affected part finally decays or dries, and the whole leaf succumbs. In severe attacks the entire plant is affected.

The downy-mildew fungus fruits abundantly on the underside of the leaf. The spores are splashed by rains, and possibly blown by wind, to other plants. Thus infection continues at a rapid rate if the weather is favorable for the growth of the fungus. The leaves that are killed later may be filled with thick-walled resting spores that can live overwinter. The following spring new infections come from the parasite living on winter spinach or harbored in the old diseased refuse and also from the fungus that lives over in the seed.

The conidia, or spores, require a low temperature of 45° to 50° F. and plenty of moisture for best germination. They will continue to grow at higher temperatures. In other words, the mildew is most destructive during a rainy period when the nights are cool and the days slightly warmer.

Control

Certain general practices that alleviate the trouble are two- or three-year rotations, plowing under deeply all diseased plant refuse as soon as the crop is harvested, not crowding the plants too closely in the row, and planting the seed in well-drained soil. If it were possible to select seed from a mildew-free field and to plant it in isolated fields, there might be no danger of the disease. It seems almost impossible, however, to be sure that the seed is not infected. Where long rotations are practiced, and no diseased crop is grown within several miles, the pathogen in and with the seed can be killed by treating the seed with hot water, 122° F. for 25 minutes.

Winter spinach harbors the mildew and furnishes the inoculum for the early spring crop. For this reason, winter spinach and early spring spinach should never be grown on the same farm.

Because spraying or dusting have not given satisfactory results in controlling spinach mildew, the only other possible measure is to procure varieties resistant to the fungus. This has not yet been successful.

BLIGHT, OR YELLOWS

The symptoms of blight (caused by the cucumber mosaic virus) begin with some mottling, as in other mosaics. As the disease progresses the symptoms become very characteristic. At first there is a slight yellowing of the young inner leaves, later they change to a yellow color, and finally die. The disease gradually spreads to the outer leaves, which in turn are changed to yellow. During this time the foliage curls and wrinkles. If the plant is affected when young, and it may contract the disease in the seedling stage, it remains much dwarfed. In the advanced stages of the disease, the plant dies.

The virus is transmitted from diseased to healthy plants by means of potato and spinach aphids. The disease appears on the spinach within twelve to thirty days after the feeding of the contaminated insect.

The virus of yellows overwinters in the root sap of living perennial plants (page 55. In the Southern States, the aphids are capable of retaining the virus from one spinach crop until the next.

Control

In localities where yellows is general, the only way to combat the trouble is to procure resistant spinach varieties. A cross was made between the Manchuria and Savoy, and the new variety which has proved resistant is named *Virginia Savoy*. Later another resistant variety, known as *Old Dominion*, was developed. These should be planted instead of other types if the disease had caused much loss. The Virginia Savoy is the more resistant of the two, but it is rather soft for shipping and inclined to seed quickly in hot weather. Old Dominion stands the heat better, is not too soft for shipping, and if planted thinly will not seed too early. Spraying or seed treatment is of no value as a direct control measure. Eradicating the aphids is helpful because it destroys the virus carrier; and the elimination of the weed hosts destroys the source of inoculum in the spring.

SWEET CORN

Insect pests of sweet corn in New York include a flea beetle that transmits a disease known as *Stewart's disease*, the European corn borer, the corn earworm, the fall armyworm, the Japanese beetle, the corn leaf aphid, thrips, and the corn sap beetle. One or more must be controlled each year in some parts of the State to have worm-free market corn or processed corn reasonably free of insect fragments.

CORN FLEA BEETLE

The corn flea beetle *(Chaetocnema pulicaria* Melsheimer) is sometimes abundant on young sweet corn to the point where the Stewart's disease, which it transmits, may reduce the crop yield materially (page 87). This happened in the Hudson Valley and on Long Island in 1950.

The beetles are more numerous in early summer following somewhat mild winters. They pass the winter in the adult stage. They appear on corn plants when only 4 to 6 inches in height. A dozen or more may be observed on each plant when the infestation is heavy.

Control

Although no field tests with the newer insecticides have been conducted in recent years to control the flea beetle and to prevent the Stewart's disease, it would appear on the basis of the infestation and consequent losses of 1950, that control measures would be justified when the beetles are commonly seen on young corn plants.

Probably one or two treatments with a 5 per cent DDT dust would be needed. A spray substitute would be 2 pounds of 50 per cent wettable powder of DDT in 100 gallons of water. Two treatments about 5 to 7 days apart should lessen the incidence greatly of the Stewart's disease.

EUROPEAN CORN BORER

The European corn borer *(Pyrausta nubilalis* Hübner) is likely to be somewhat destructive to sweet corn wherever it is grown in the State. Commercial injury has been encountered in recent years on Long Island, in the Hudson Valley, in the far north section of the State, and along Lake Ontario and Lake Erie. The injury inflicted is a result of the feeding of the worms in the maturing ears and in the stalks. It has been especially severe in seasons when weather conditions are favorable for borer development, and in market-garden areas where two generations of the borer appear annually. In some areas, however, such as those bordering on Lake Ontario and in the Syracuse section, serious injury may be caused by a single annual generation of the borer.

The first evidence of injury by the borer can be seen when corn is from 12 to 18 inches high. It is represented by small pinlike holes, or slightly larger irregular shaped holes, eaten into the leaves or midrib by very small borers that have just hatched. Recognition of this type of injury, followed by the finding of borers ¼ inch long in the "throat" of the corn, is important to growers who plan to make spraying or dusting treatments designed to control the borer. Larger worms bore into the unfolding tassel or into its base and cause the tassel to shrivel or to break over. The final and the most destructive injury is the feeding of borers among the rows of kernels in the ears.

When two broods of the borers are present, these different types of injury are evident on early maturing corn, or during July and early August, and on corn maturing in September and early October. When one brood is present, most of the injury is manifest in August but some injuries may extend throughout September to a lesser degree.

The corn borer passes the winter as a fully grown worm in its food plant unless it is disturbed, in which case it may migrate to some more suitable shelter. It can be found, therefore, in weed stems growing near an old cornfield, or in bits of corn debris left protruding from the ground, the old stalks or stubble of which have been plowed under. In the spring these larvae transform to pupae, and from ten days to two weeks after this transformation the pupae produce moths.

The early generation of the two-brooded strain of the borer, understood to be present on Long Island, in the Hudson Valley, and perhaps in smaller areas along Lake Ontario, produces a second brood of borers when its moth stage matures in July and early August, and lays eggs on

corn planted so as to mature late in the growing season. The borers from this second brood of moths are those which pass the winter in a fully grown condition in cornstalks and sometimes in weeds.

The moths lay their eggs mostly on the underside of the leaves in flat, compact clusters of from 15 to 20 eggs. They are laid shingle-like, one over the other in the cluster. Each egg is thin and scale-like. This stage appears to be a crucial one in the life history of the borer, for under hot weather conditions these eggs do not seem to develop well and may perish before hatching. Under average or cool weather conditions, development of the eggs is normal. Each female moth is capable of laying up to about 400 eggs. On hatching, the young corn borers may feed as described and become full grown in about a month. During the period of egg laying, it is not difficult to detect the moths flying from one cornstalk to another stalk about 15 feet away when they are disturbed by one's approach.

The borer attacks also a number of cultivated crops, such as rhubarb, beets, potato vines, peppers, celery, and lima beans, but the infestation is not likely to be severe unless these crops are grown near infested cornfields. Flowering plants sometimes infested are dahlias, chrysanthemums, and gladioli. Among the weeds sometimes found infested are barnyard grass, coccleburr, smartweed, ragweed, and pigweed.

Control

Insecticides

The most effective way to control the European corn borer in sweet corn is by the use of insecticides. It is now practical and profitable to treat market sweet corn when a price of $2 or more per 100 ears can be expected. The insecticidal treatment of early market sweet corn has been particularly profitable. The treatments are designed to kill the newly hatched borers on the plant surfaces before they have entered the interior. To protect the plant over the usual egg-laying period, a series of four treatments at five-day intervals is normally required. To be most effective, the insecticide must reach the crowns, leaf axils, and, in later treatments, the developing ears. Applications should start shortly after the first eggs have hatched. At this time the plantings to be protected are usually from 12 to 18 inches high and "pin hole" injury of the type mentioned may be found. The exact date of the first treatment depends on the season and the locality. Treatments are normally begun during the first ten days of June in eastern New York and about one week later in western New York. Second-generation treatments in eastern New York are normally begun at about the end of the first week in August. Applications should be repeated if heavy rains occur immediately after treatment.

Control with Insecticides in the Two-generation Area

Infestations of this insect in sweet corn are difficult and costly to control; however, a profit on the cost of the control can be achieved if four dust or spray treatments are made at timely intervals and if the insecticides are applied with thoroughness. Success in controlling the borer depends also upon some knowledge of the activity and habits of the borer. Such knowledge includes recognition of the egg stages of the insect, of the symptoms, and of the feeding habits of the young and newly hatched borers. A corn grower should know when the borer is not likely to develop into a serious pest due to unfavorable weather conditions, for at times it would be wasteful to continue field treatments of corn even though the first of four recommended treatments has been made on the advice of a county agricultural agent or another authority. At other times additional treatments need to be made if it appears that the eggs are hatching and some feeding of young borers is evident. If the grower has experienced

severe infestations in recent years and is inclined to control the borer with insecticides, probably it will be advisable to make the first treatment at the proper time and to determine then whether further treatments need to be made.

The importance of timing the first of four treatments cannot be overemphasized. Since the exact date for the first treatment varies with the earliness or lateness of the season, it must be based on observations made to see when the moths of a given brood are beginning to lay their eggs. Growers may obtain this information from the county agricultural agent.

Insecticides, both in dust and spray form, have given good results, although in New York dusts have usually been more practical to apply. Small plantings may be treated with bellows-type knapsack dusters which require about 2¾ man hours and 40 pounds or more of dust per acre for each of the four recommended applications. Tractor-mounted power dusters are capable of treating from 4 to 5 acres an hour, although, because of less accurate placement, from one and one half to two times this amount of dust may be required for comparable results. Since most insecticidal dusts are applied to low-growing, early market sweet corn, experience has shown that dusters mounted on ordinary farm tractors are entirely satisfactory. No significant mechanical injury may be expected if care is taken to apply the later dust treatments when the corn has grown higher and during the middle of the day when the plants are flexible rather than in the early morning or in the evening when the stalks are more brittle.

In recent years commercial sweet-corn growers have used successfully also the high-boy type of duster and concentrate sprayer. This is a self-propelled three- or four-wheeled machine which can straddle the tops of well-grown corn without injury to it.

The most effective dusts for use against the corn borer are those containing Ryania, rotenone, DDT, and parathion. Ryania, and rotenone are non-poisonous. DDT and parathion are somewhat hazardous to the person applying them.

Ryania dust should contain 40 per cent active ingredients. Rotenone and parathion dusts should be used at 1 per cent strengths. The DDT dust should be used at 5 per cent strength, but probably it should not be used if the treated corn is to be fed to milk cattle.

Any of these insecticides can be used as sprays. Ryania can be used at the rate of 6 pounds of the 100 per cent undiluted powder to 100 gallons of water together with a suitable amount of a spreading agent. The DDT is advised at the rate of 2 to 3 pounds of the 50 per cent wettable powder to 100 gallons. Rotenone is used at the rate of 4 pounds of the 4 or 5 per cent powder to 100 gallons. Parathion wettable powder is diluted at the rate of 1½ pounds of the 15 per cent wettable powder to 100 gallons of water. Sprays should be applied with a boom that has 3 nozzle outlets directed toward each row in such a way as to insure complete coverage.

Concentrate sprays of DDT have been used in recent years with some success to control the borer. These apply the equivalent of about 1½ pounds of actual DDT per acre at each application, the DDT being dissolved in an oil base, which may or may not be diluted in water.

Cultural Practices

The proper disposal of crop remnants and the adjustments of planting dates to avoid harvesting during peak periods of borer activity have been standard recommendations since the insect first became established in the United States. These practices should be encouraged whenever possible, although they may not of themselves always give satisfactory borer control when conditions of heavy infestation occur in New York. Cutting cornstalks as low and as early as possible, clean plowing, shredding stalks used for fodder, and the careful feeding or burning of borer-in-

fested stalks in barnyards are measures that destroy large numbers of borers. It should be emphasized, however, that ordinary farming operations probably destroy, on the average, more than 80 per cent of the stalks and hibernating borers. The effectiveness of clean-up measures for borer control depends on the thoroughness with which the remaining stalks and borers are eliminated. Stalks and stubble may be plowed under in the fall or in the spring before May 25. Such plowing should be thorough, to the point where all corn remnants are covered with soil. This treatment is especially helpful when early plantings are plowed under or the stalks are fed to livestock immediately after the ears have been harvested. In such plowing, a chain attached to the plow and dragging in the furrow often helps to get large stalks underground. Discing and harrowing in themselves are not satisfactory ways to kill borers in the old cornstalks or stubble. Borer injury may be reduced by planting sweet corn so that it will be harvested during the first three weeks of August in eastern New York and during late August and September in western New York. This practice is not feasible when a succession of plantings is desired.

CORN EARWORM

One of the serious insect enemies of sweet corn is the earworm *Heliothis obsoleta* Hübner) which feeds for the most part on the developing kernels at the tip of the ear. The mere presence of the earworms and their abundant, unsightly excrement often is enough to lower the value of a crop. The earworm has a tan-colored head and is 1¼ inches long when fully grown. The body has prominent longitudinal stripes and may vary in general color from yellowish green to black, with shades of pink or brown. It should not be confused with the European corn borer which seldom exceeds 1 inch in length, is dirty white in color, with a dark brown or black head. The borer, unlike the earworm, commonly attacks all parts of the ear and frequently tunnels into the ear.

The most serious earworm injury in the State is on Long Island and in the lower Hudson Valley. Corn in other parts of the State may be affected less, particularly during part of the growing season. The earworm does not seem able to pass the winter successfully in upper New York although it has been demonstrated that at least some overwintering pupae are able to survive on Long Island when conditions are favorable. It is believed that a substantial part of the earworm infestations in the State originates from moths that migrated from the South. There are two generations, and possibly a third, each season on Long Island and in adjacent parts of the lower Hudson Valley. In these areas earworm injury occurs in July and from late August to the end of the season. In upper New York a single generation, usually in limited numbers, affects principally late-maturing sweet corn.

Eggs are usually laid by the moths on fresh corn silks, and hatch in about three days. The newly hatched worms pass through the "silk channel," feeding along the way, to the kernels of the developing ear where feeding continues until larval development is complete. Seldom does more than one worm reach maturity in any given ear because of a well-developed cannibalistic tendency.

Control

The corn earworm has proved difficult to control on a practical commercial basis. Present control practices are the introduction of a mineral oil containing an insecticide into the tip of the ear, or the spraying or dusting of the ear tassel with DDT or parathion.

The ear-injection treatment uses a medicine dropper or an especially designed applicator to force 15 drops of a heavy U.S.P. mineral oil containing 0.2 per cent pyrethrins or 2 per cent of dichloroethyl

ether into the silk channel just after pollination is completed. This is just after the tip of the silks turn brown. Should the ear development vary greatly, a follow-up treatment is necessary a day or two later for those skipped at the time of the first treatment. Those ears treated earlier should be indicated by a crayon marking or otherwise. One gallon of oil is enough to treat the ears of about two-thirds of an acre.

The DDT control method uses either a 5 per cent DDT dust or an oil-base concentrate containing DDT or parathion. Either one must be directed to the silks of the ears to get good control. In dusting or spraying, two nozzles need to be set at the ear level. The proper setting and direction of the nozzles is equally important as the insecticide, to obtain efficient results. In 1950, the 5 per cent DDT dust was somewhat more effective than the spray.

A 1 per cent parathion dust was also found effective when used at the rate of 40 pounds per acre. This insecticide is more hazardous to the operator than a 5 per cent DDT dust, and full directions must be followed to protect the user from harmful effects.

Sprays used by some growers included 3 gallons of 25 per cent DDT emulsion plus 7½ gallons of mineral oil of 60 to 90 viscosity in 90 gallons of water. This was used as a concentrate at the rate of 25 gallons per acre for each application. Another spray formulation consisted of 1 gallon of a 25 per cent emulsion of parathion plus 7 gallons of mineral oil of 60 to 90 viscosity in 92 gallons of water, and used at the rate of 25 gallons per acre per application. A grower would need to be especially cautious when using this parathion emulsion concentrate, otherwise harm might overtake the person applying it.

To get nearly complete control of the earworm under conditions of a heavy infestation, a grower must make three applications at three-day intervals. The important object is to keep the silks fairly well coated with an insecticide during the egg-laying period of the moth.

Earworm control does not need to be practised on all plantings in a given area of the State. A grower needs to examine the maturing ears of early plantings for earworms. If they are found to infest as many as 10 per cent of the ears, it would seem profitable for him to treat all later maturing plantings when the ear silks of those plantings have reached the proper stage. County agricultural agents keep well informed of earworm infestations and can be consulted for timely information on this subject.

FALL ARMYWORM

Another insect known as the fall armyworm *(Laphygma frugiperda* A. and S.) sometimes combines with the corn borer or the earworm to injure ears to the point where they are not marketable. This insect appears to some extent every year in late August on Long Island and in the Hudson Valley.

The worm stage feeds upon the leaves and has a tendency to rag them. When it is about mature it has a tendency to bore into the side of the ear and to feed upon the kernels.

Control

The same insecticides used to control the earworm are effective against the armyworm. The number of treatments, however, must be increased from three, as advised for the earworm, to five. The two additional treatments are made at three-day intervals just before those advised for the earworm. Sometimes a total of four treatments spaced over a five-treatment period gives commercial control of an infestation of both the earworm and the armyworm.

JAPANESE BEETLE

In recent seasons the Japanese beetle *(Popillia japonica* Newm.) has appeared as a pest even in corn plantings of more than

FIGURE 19. JAPANESE BEETLE
About three times natural size

FIGURE 20. GRUB, OR LARVA, OF THE JAPANESE BEETLE
About three times natural size

100 acres when it was found feeding upon the silks of maturing corn ears. Its feeding is harmful when the young silks are chewed off before pollination is completed. This degree of silk destruction readily follows when three or more beetles cluster on the silk of one ear.

Effective control was procured in 1949 on Long Island and in the Hudson Valley when one application of a 5 per cent DDT dust was applied with a high-boy self-propelled duster or by airplane at the rate of 40 to 60 pounds of the dust per acre. An effective kill was procured also when an airplane applied 1½ gallons of water added to ½ gallon of a 25 per cent emulsion of DDT per acre. It was observed, however, that thorough coverage of the corn was necessary to get a satisfactory kill and this could be procured by aircraft only under highly favorable flight conditions.

CORN LEAF APHID

In recent years the tassels of some varieties of sweet corn have become very heavily infested at times with a species of green aphis (*Aphis maidis* Fitch). It has been reported as inflicting commercial injury to some varieties of growing corn by causing incomplete pollination. Growers complain at times that the aphids migrate to corn ears in such numbers as to be objectionable to the point where ears are not marketable.

Efforts have not been made to control the aphid. Should this be thought necessary it would seem that a 1 per cent parathion or a TEPP dust, or a 3 per cent nicotine dust would control it. The equivalent sprays of these insecticides used for cabbage aphid control (page 29) should also be effective.

THRIPS

Several kinds of minute insects, known as *thrips*, appear in such numbers on young corn in rather dry periods that they slow its growth. The feeding of the thrips on the lower surface of the leaves causes them to assume a pale green color. Badly infested leaves wilt and dry.

It has never seemed necessary to apply an insecticide to control the thrips on corn because timely rains cause the corn to outgrow the temporary slowing up of growth. If control treatments are thought advisable, a 5 per cent DDT or a 1 per cent parathion dust could be used at the rate of 40 pounds per acre. One treatment ought to check the increase in numbers of the thrips so further injury will not be serious.

CORN SAP BEETLE

A small beetle (*Carpophilus dimidiatus* F.) has been observed in objectionable numbers in recent years on the silks of corn ears and in tunnels made by worms that feed upon the stalks and ears. It is understood that this beetle feeds primarily upon the fermented parts of corn, includ-

ing the excrement of the worms. It is therefore not regarded as a primary pest.

Complaints have been received, however, that its presence is objectionable at times when the ears are marketed. Other objections to its presence on the ears have been made by some who process corn.

No field-control tests have been made against the sap beetle. It is possible that a 5 per cent DDT dust would control it.

SMUT

The smut of corn (caused by *Ustilago zeae*) was probably present when the white man first came to America. It is now present in nearly all countries where corn is grown, being of great economic importance in North America.

Sweet corn is more susceptible than is field corn, and under very favorable conditions may become infected during the seedling stage.

The corn plant may be infected at any time in the early stages of its development, but gradually grows less susceptible after the formation of the ear. Any part of the plant aboveground can be invaded, although it is more common to see smut boils on the ears, the tassels, and the nodes than on the leaves, the inter-nodes, and the aerial roots. The boil is composed of a white smooth covering enclosing a great mass, sometimes 4 or 5 inches in diameter, of black greasy or powdery spores. After the maturity of the spores, the covering becomes dry and brittle, breaks open, and permits the black powdery contents to escape. The smut spores are blown long distances by the wind and are particularly prevalent if there is much dust in the air. They will germinate in ordinary rain water but germinate very much more prolifically in the drainings from barnyard manure. Consequently, it is scattered over the farm with manure and has been known to pass through the digestive tract of animals without losing its germinating ability. The germ tube of the germinating spore ordinarily does not enter the plant directly, but a few drops of dew caught in the leaf sheath will remain long enough for the fungus to start a luxuriant growth, and it is only when it is growing in this manner that it can enter the plant.

Hot dry seasons are favorable for the growth of the smut fungus, although drought is only indirectly the cause for the smut to increase. When the soil is dry, the dust can blow more readily, and it is by means of air-floating dust that the fungus spores are carried from one farm to the other. Furthermore, when there is a drought, the temperature usually is high, which is especially favorable for the germination of the spores. It, however, must have water collected in the silk, leaf-blades, and other parts of the corn, to get the required amount of growth for penetrating the tissue.

Control

It is to be remembered that the seed dealer or the seed grower is not to be blamed for the smut that the gardener may have on his crop, for the smut is not transmitted with the seed. Therefore, seed treatment is never of any value.

The recommended control measures are rather unsatisfactory. If every grower in a given community will go through his field two or three times during the season and cut out all of the smut balls before they have time to break open, and remove them in some receptacle that will not permit the spores to spill out, the smut can be reduced. The material that is cut out should be buried deeply or placed on a hot enough fire to be destroyed. One year of cutting is not enough to cause much difference in the amount of the disease, but, if this cutting is continued for two or more years, the smut will gradually be eliminated. This is true, however, only if adjoining neighbors cooperate in following the same recommendation. The removal of the smut should always be accompanied by rather long crop rotations.

There is some degree of resistance to smut among some of the newer varieties. In one test on Long Island, Marcross had 21 per cent smut, Lincoln 19, and some unnamed crosses as low as from 4 to 15 per cent. Under the same conditions, Carmel Cross had 39 per cent, Golden Cross had 33, and some other varieties had as much as 65 per cent smut.

In New Jersey, dusting for European cornborer control also reduced the amount of smut.

BACTERIAL WILT, OR STEWART'S DISEASE, OF SWEET CORN

During the seasons of 1931 to 1933, sweet corn grown along Lake Erie, in the lower Hudson Valley, and on Long Island, was seriously affected with the bacterial wilt (caused by *Bacterium stewartii*). Reports came also from New Jersey, Pennsylvania, and Ohio that an epiphytotic of this disease was present in these States. Such a condition was unusual since the bacterial disease in past years had never been threatening. In 1934 to 1946, owing to the absence of the insect carrier, very little wilt was present in up-state New York. Since 1947 there has been an increase so that in 1950 it was severe in the lower Hudson Valley and present in varying degrees as far north as Poughkeepsie during 1952 and 1953. When the averages of the mean temperatures of December, January, and February add up to 98 or more, the disease is likely to be present. The lower the sum of these averages, the less possibility of infection the following summer.

The very early yellow varieties of sweet corn now being grown so commonly are much more susceptible than are the older, late-maturing, white types, that are fairly resistant. Popcorn and flint corn also are fairly susceptible, while the dent field corns are attacked only under the most favorable conditions.

The disease makes its appearance at any stage of growth, but usually is most noticeable when the plants have attained a height of several feet. The plants are dwarfed, the tassel develops prematurely, whitens, and dies early, the leaves dry out one by one much as if frosted, and finally the stem dies and dries, but without becoming soft rotted. A yellow slime ooze may collect on the surface of the inner husks. If the stem is cut off near the base and pressed, a similar yellow ooze collects at the cut ends of the "strings" in the stalk. This is the one means by which the disease can be differentiated from any other corn trouble.

It has been proved that the bacterium can live through the winter in the seed and in the old diseased stalks. It has been shown also that the parasite remains alive during the winter within the adult flea-beetles *(Chaetocnema pulicaria)* which commonly feed on young corn early in the spring. The pathogen then is further disseminated by the twelve-spotted cucumber beetle (southern corn-root maggot).

The bacterium is most susceptible to environmental conditions, and especially is this true since it must depend largely on the flea-beetle for overwintering in the field. If cold weather (sum of average mean temperatures is below 98) kills these insects, the source of local inoculum is eliminated almost entirely unless affected seed is planted. The amount of rainfall at planting time too has a great influence on the severity of infection, as heavy rain is especially favorable for the bacterium. In addition, the date of planting is most important; the earlier the seed is put into the ground, the more chance there seems to be for heavy infection.

Control

The infected plants should be destroyed, either by burning or placing into the silo, as soon as the harvesting is completed. Fall plowing, turning the stubble under deeply, also is of help. Furthermore, next season's sweet-corn crop should be planted

as far from the present field as possible. If susceptible varieties must be planted, the seed should be obtained from the North so that there is less chance of seed infection. Fortunately the disease has not been present in the northern half of our State during recent years. Planting should be delayed as long as the market price or timing of maturity will permit. Even the most susceptible varieties may sometimes be grown in a comparatively healthy condition if they are planted late.

The best method of control is the use of resistant varieties. Such strains as Golden Cross Bantam, Ioana, Carmelcross, Marcross, Lincoln, Lee, and many others can now be obtained from local seed dealers. Most of the extra early hybrids are not resistant. Even late-maturing varieties may be susceptible in the seedling stage.

Seed treatment has been advocated, but did not prove successful where the insect carriers were numerous.

In cooperation with the weather bureau, it may be possible to predict serious epidemics early enough in the spring so that every control measure can be applied intensively.

TOMATO

YOUNG tomato plants are sometimes chewed off at ground level by cutworms. Flea beetles are sometimes injurious to newly set plants as they eat numerous pinholes in the leaves. Potato beetles and their slugs may injure the foliage by their feeding. The potato aphid may retard plant growth when this insect develops in enormous numbers and sucks the sap from the terminals and leaves. Hornworms are occasionally a pest as they defoliate the plants by their feeding. Stink bugs prevent the fruits from ripening into a uniform red color in small areas adjacent to their feeding punctures. With the development of a disease-control program by dusting or spraying in the commercial, cannery-tomato growing areas, insecticides can be included at times in the treatments to advantage.

CUTWORMS

The control of cutworms is described on page 97. A cutworm bait is effective if applied properly and timely. A 5 per cent DDT dust or a 5 per cent chlordane dust applied rather heavily around the base of plants that are being attacked gives good control.

POTATO FLEA BEETLE

A small, black, jumping insect known as a flea beetle (*Epitrix cucumeris* Harris) usually attacks tomato seedlings in the plant bed, or causes commercial injury to tomato plants just after they have been set in the field. These insects are from 1/16 to 1/12 inch in length. They are commonly known as "fleas." The beetles feed on both the under and upper surface of the leaves and eat small holes about the size of the head of a common pin. The injury is more serious than growers generally suppose, especially if it is desired to harvest tomatoes early in the season as is possible. Often the badly injured lower leaves of newly set plants are so injured that they turn brown, wilt, and die. It is economy to prevent this injury.

Control

A ¾ of 1 per cent rotenone dust is effective. A substitute dust is a 15–85 calcium-arsenate – lime dust, although the lime in this dust may be detrimental to the early blossoms and cause these to drop. A 3 per cent DDT dust gives excellent kills, and could well be applied to tomato plants while they are still in the flats and just before they are set out, to protect them for some days against flea-beetle injury. A DDT spray, prepared by mixing 1 pound of 50 per cent wettable powder of DDT or 1 pint of 25 per cent emulsion

of DDT, each in 50 gallons of water could be substituted for the DDT dust.

COLORADO POTATO BEETLE

The Colorado potato beetle may be found feeding on the young tomato plants in its adult or immature slug stage. It is readily controlled by any of the sprays and dusts described for the control of flea beetles.

APHIDS

Tomato plants growing in the field sometimes become infested with colonies of the pink and green potato aphid *(Macrosiphum solanifolii* Ashmead) and occasionally with other species of aphids that may be present in small numbers on plants grown in and shipped from the South. When such infestations are observed at planting time, the plants should be treated with one of the spray or dust combinations advised for the control of aphids on page 29. This treatment should not be overlooked because a mild aphis infestation at transplanting time may develop into a commercially serious infestation later in the field which would entail considerable expense to control.

Destructive infestations sometimes appear on tomatoes in summer. Colonies develop first on the undersides of the compound leaves and later on terminals and on flower stalks. Whenever twenty-five or more aphids are seen on the lower surface of a leaf on a plant here and there in the field, and the plants are just beginning to set fruit, it seems advisable to make a control treatment. The directions supplied on page 29 for the control of the cabbage aphid should be followed.

TOMATO HORNWORM

Tomato foliage is sometimes attacked by large green or brown caterpillars *(Phlegethontius quinquemaculata* Haworth) which, when full-grown, are 3 or 4 inches in length (cover illustration). These caterpillars, because of their large size and their voracious appetite, are able to eat a great quantity of leaves and may defoliate the plant. Fortunately, they rarely become too abundant in New York. The insect is present in small numbers each year.

Control

In small plantings, the hornworm can be controlled readily by handpicking. The worms with the white cocoons on their backs should not be destroyed because these are parasites of the worms and are beneficial.

Effective hornworm sprays are 2 pounds of 15 per cent wettable powder of parathion or 2 pounds of 50 per cent wettable powder of chlordane, each to 100 gallons of water. The parathion should not be applied within fifteen days, or the chlordane within twenty-one days of harvest. The insecticide DDD has also been found to give good kills of the hornworm on tomatoes.

STINK BUGS

The green stink bug *(Nezara viridula* L.) feeds in its adult and nymphal or immature stages on green or ripening tomato fruits. It punctures the skin with its sucking mouthparts. The area around the puncture beneath the skin then becomes corky and hard, and the skin surface around the puncture fails to develop its full red color. This condition interferes with good cannery practise, and tomatoes so affected may be thrown out of grade.

Control

No extensive control of the stink bug has been practised under field conditions. A grower who has had difficulty with this insect and has the equipment for spraying or dusting might wish to try parathion, using a 1 per cent dust or a spray consisting of 1½ pounds of 15 per cent wettable powder of parathion in 100 gallons of water. Parathion is effective against the group of insects to which this stink bug belongs.

In controlling this insect it should be

borne in mind that it develops commonly upon weeds and grasses, and that the insects are likely to migrate to tomato fields from adjacent weedy areas, or even to develop upon grasses and weeds within the tomato field. Two or three treatments at weekly intervals may be necessary for complete control.

BACTERIAL CANKER

Bacterial canker (caused by *Corynebacterium michiganense)* only of late years has caused any particular damage in the State. The first symptoms of the trouble are wilting, rolling, and browning of the leaves on one side of the plant. The pith may disappear or become discolored. In severe cases the whole plant dies. When the soil is infested, the fruit becomes infected and shows the "bird's-eye" spots.

The bacterial canker disease may become complicated by the presence of other bacterial organisms in the diseased tissue. The causal organism inhabits, primarily, the food-conducting tissue of the plant; later, collapsing this tissue, it may extend into the pith or through cracks of the stem to the outside of the plant. It overwinters on the seed and in the old diseased plant refuse, and in the South is known to remain alive in the soil for more than a year.

Control

Care should be taken to select seed only from healthy plants. Plowing and complete destruction of tomato refuse should be practiced, as the organism may overwinter in tomato refuse. It is advisable to rotate crops so that tomatoes are grown on the same area only once in three or four years. They should never be grown in a field adjoining an area where disease occurred the previous year.

The seed should be treated in hot water, 122° F. for 25 minutes (page 33), and then immediately soaked for an hour in a blue-vitriol solution, 2 ounces in each gallon of water. The seed then is dried and may be planted later. The seed may be dried immediately after the hot-water treatment, and then dusted with Arasan, 1 level teaspoonful for each pound of seed just before planting time.

EARLY BLIGHT AND SEPTORIA BLIGHT

Early blight and Septoria blight (caused by *Alternaria solani* and *Septoria lycopersici)* may cause much damage on the foliage of tomatoes, and the early blight may also cause rotting of the fruit. The early, or Alternaria, blight is the same as that found on the potato, and is the cause of

FIGURE 21. BACTERIAL CANKER SPOTS ON TOMATO FRUIT

the leaf-spot so prevalent in New York State. The Septoria blight rarely causes much damage so far north as New York unless the seed or plants have been grown farther south.

Early blight is characterized by brown spots, with concentric rings on the leaves and black-rot spots on the fruit, especially at the stem end, and Septoria blight by small whitish spots, with minute black fungous fruit bodies on the leaf. Both cause defoliation of the plants, and for this reason may result in sunscald of the fruit later. The early blight may cause also damping-off and collar-rot at the base of the stem.

Both fungi are carried in the old diseased plant refuse and will remain alive in the soil at least as long as the tomato stems are not completely rotted. They are carried also on or in the seed. Related weed hosts may keep the two fungi alive for a long time in any given field.

Both parasites grow best in wet weather, and are aided in their dissemination by the splashing of rain. Both require a fairly high temperature for abundant infection. The spores of the Alternaria will germinate best at about 80° F., while the Septoria has a range of 60° to 80° F., with the optimum at about 75° F. Therefore, in a uniformly cool season the diseases do not spread so rapidly.

Control

Aside from more detailed control measures, the following general recommendations are offered: Plowing under deeply all diseased refuse directly after harvest, three-year or longer rotations with crops not belonging to the tomato family, destruction of all weeds related to the tomato family growing in the field or within 50 feet of the field; great caution in guarding against the possibility of getting diseased refuse in the seedbed, and the procuring of seed from perfectly healthy fruit. If southern plants are bought, they should be guaranteed free from the collar-rot.

The two important measures, however, are treatment of seed with hot water (page 33) and spraying the plants alternately in the seedbed with a Ziram solution, 2 pounds in 100 gallons and an insoluble copper compound, 4 pounds in 100 gallons of water or 2 ounces in 3 gallons. An insecticide may be added as recommended for the control of flea beetles (page 25). In the seedbed, the spray may be put on with a hand sprayer. In the field, spraying should be done with a traction or engine-driven sprayer, and the nozzles so arranged that especially the lower and inner parts of the plant are covered. The applications of spray in the seedbed should be made at five- to seven-day intervals, beginning as soon as the plants break through the ground.

In the field, five or more sprays should be applied at approximately ten-day intervals. The first spray should be made just before the plants are large enough to fall over. This is about July 15 in upstate areas. The second is made from July 25 to 28; the third and following ones at seven- to ten-day intervals, depending on the degree of possible infection from blight or anthracnose. Orthocide 406 (4 pounds in 100 gallons), Manzate or one of the Ziram group of sprays (page 109) used at the strength of 2 pounds in 100 gallons of spray and with some commercial spreader, such as Orthol-K or Dupont Spreader, is suggested for the first two sprays. The third spray should be with bordeaux mixture or some other form of copper; the fourth, again with the Ziram provided no late blight is present; and the fifth with bordeaux. If desired, Manzate can be used alone for all the sprays. Manzate or a Zineb type of spray, if applied twice a week, can replace the copper sprays for the control of late blight. The Manzate controls also anthracnose, Alternaria blight, and Cladosporium leaf mold. Two hundred gallons to the acre are required for good disease control. Early tomatoes probably do not need spraying in the field. The seedbed applications, however, should not be neglected.

Insoluble copper, Orthocide 406, or Ziram dusts may be used instead of the sprays, and give fairly satisfactory results, if the dust is driven upward into the plant as well as downward, and at least 7 per cent metallic copper is present in the dust, or 10 pounds of Ziram or 406 with 90 pounds of talc.

Some varieties are much more resistant to leaf-spot than are others. The Ponderosa, John Baer, and Earliana are rather susceptible, while the Stone, Norton, and Marglobe are fairly resistant.

The Septoria blight fungus can be controlled without field spraying by planting New-York-State-grown seed that has been hot-water treated, accompanied by a four-year crop rotation and eradication of horse-nettle in areas where this weed is a menace. The Alternaria blight is much reduced by turning under a legume sod, using appropriate amounts of fertilizer, and keeping the ripe fruit picked from the plants.

RIPE ROT, OR ANTHRACNOSE

Ripe rot, or anthracnose (caused by *Colletotrichum phomoides*), probably is the most serious disease affecting canning tomatoes. The loss results not only from the rotting of ripe fruit before and after picking, but also from the exceptionally high mold count in the canned product when only a very small proportion of inconspicuously diseased fruits are present.

The host relationships have not yet been determined fully. Some investigators believe that the anthracnoses on tomatoes, apples, pears, bananas, and a host of other crops are caused by the same fungus. Judging from a microscopic study, the one commonly found on apple is not the same as the one on tomato, even though one species or strain from apple and another from squash may infect tomatoes seriously.

In the early stages, the lesions appear simply as small, circular, sunken spots in the skin, much as though the surface had been indented with a match-head or lead-pencil eraser. As these spots increase in size, the central portion becomes dark because of the presence of black fungous structures just beneath the skin. Eventually the entire fruit becomes affected, often developing a watery rot where various other organisms enter. Microscopic examination of the pulp beneath even the smallest spots reveals the presence of the fungous spores in enormous numbers. Under proper conditions, spores may be produced also in great numbers on the surface of the spots, giving a somewhat slimy tan or salmon-colored appearance.

The fungus lives over winter not only in old diseased vines but also on and in seed. In the seedbed and later in the field, spots, which the casual observer would overlook entirely, occur on the foliage and stems. Even though the fruiting is sparse on these infection areas, it enables the fungus to remain alive until mature fruits are available. Green fruit can be inoculated successfully, but the lesions do not develop until ripeness begins. Although the fungus can enter uninjured fruit, infection is much more prevalent where there are insect stings or other breaks in the epidermis. When the fruit is ripe and the weather is favorable, spots develop all over the fruit and bear an innumerable mass of spores, each of which is capable of reproducing the fungus when it is splashed to other tomatoes or another area of the same fruit.

The pathogen will grow at temperatures of 55° to 95° F., but the optimum is 80° F. Therefore, when the temperatures are unusually high and the rainfall for August is excessive, there may be an epidemic of the anthracnose.

Control

The control measures are, with one exception, the same as those listed for early blight (page 91). Copper is not toxic enough against the Colletotrichum, so that a more effective fungicide is desirable. For this reason, the copper sprays are

alternated with Ziram sprays, 2 or 3 pounds in 100 gallons of water, or Orthocide 406, 4 pounds, with a suitable spreader. Manzate (2–100) has proved especially effective against anthracnose. The schedule usually is the same as that suggested for late-blight control (page 96); but if the weather continues hot, the copper should be replaced by Manzate, Ziram, Orthocide 406, or Ferbam.

LEAF-MOLD

Few greenhouse tomatoes escape entirely the presence of the leaf-mold fungus (caused by *Cladosporium fulvum*), and in seasons such as 1951 field-grown tomatoes in New York State also may be affected. The disease begins as light yellow spots on the upper side of the leaf. On the corresponding lower side, greenish or purple mold soon appears. Finally, the leaf tissue dies and the leaf curls up and drops. The mold is seldom found on the stem, and is difficult to detect on the fruit.

The disease is caused by a fungus that lives over in the seed and in the old diseased plant parts that are not destroyed at the end of the season. The parasite is splashed from plant to plant during the watering, and may also be carried by insects. The mold is very sensitive to dryness and this in turn is determined largely by the light and the temperature in the greenhouse. The fungus grows best at 55° to 70° F. when the soil or the air contains much water. Consequently the disease is present in greatest abundance where the greenhouse is cool and not well ventilated.

Control

Since the leaf-mold must depend for growth on almost a completely saturated air, one of the control measures is the proper manipulation of the greenhouse to keep the humidity too low for growth of the fungus. Some of the steps in obtaining this condition are: to wet the plants as little as possible when watering, to keep the ventilators open even if extra coal is required for heating the house, to let in all the sunshine available, and to plant the vines far enough apart so that air can circulate among them.

In some houses it has been found profitable to install fans of various types to move the otherwise stagnant air. The dry, warm air is drawn into the house and the water-laden air is expelled. This movement takes care of the immense amount of water given off by large tomato plants, for air moving at only one-half mile an hour has twice the evaporating possibilities of still air. In addition, it eliminates air pockets which are present even though the ventilators are wide open.

If no fans are available, fairly satisfactory results can be obtained by having continuous ventilator openings both at the top of the house and along both sides near the ground. If the plants are set in rows crosswise of the house so the air currents can follow down the row, the exchange of air will progress rapidly. This can be facilitated also by planting two rows closer together and the next two rows farther apart. This will permit the usual number of plants in a given space and at the same time will give the air currents wider lanes through which to move unobstructedly.

If the mold is present in cold weather, lowering the night temperature of the house to 50° F. for several nights in succession checks the growth of the parasite. This lowering of the temperature should be practiced as much as good growth of the plants will permit.

The resistant varieties, Bay State and Vetomold, are satisfactory where only one strain of the fungus is present. In most greenhouses, however, a second strain has become established, so the selection Vetomold 121 or the Improved Bay State is required.

Spraying at weekly intervals with Manzate, Ziram, or Ferbam, 2 pounds in 100 gallons of water, has given commercial control both in the greenhouse and in the field if the applications were begun when

the plants had attained half their vine growth and the spray directed to all parts of the vines, but especially to the lower surface of the foliage.

BACTERIAL SPOT OF TOMATOES AND PEPPERS

During warm seasons, bacterial spot (caused by *Xanthomonas vesicatoria)* may become a serious disease of tomato and pepper. Although seedlings may be attacked, the most serious losses are on the fruit which is disfigured. The young lesions on the fruit are dark raised spots, usually with a narrow watersoaked border. The older lesions are black and elevated with irregularly lobed margins. The center of the lesions becomes slightly sunken, brown, and corky and usually does not penetrate very deeply into the pulp of the tomato. On pepper fruit, the lesions remain more superficial. The symptoms on the leaves are not so noticeable as on the fruit. At first the spots are very small, water-soaked, and translucent. Later the enlarged spots turn black in the center and become sunken on the lower side of the leaf. Severely infected leaves turn yellow and finally become brown and dry. The tomato strain can always infect peppers, but the one from peppers does not always infect tomato.

Bacterial speck rot (caused by *Pseudomonas tomato)* causes in wet weather symptoms like those of the bacterial spot or in dry weather makes numerous black stipples on the fruit. The life history and control are the same for the two pathogens. It does not infect peppers but has been inoculated successfully with eggplant.

Control

The diseases can largely be eliminated by use of disease-free seed and by growing tomatoes in soil that has not borne tomatoes for three years. If seed, bought on the market, is not known to be free from the bacterial spots, it should be treated with hot water (page 33). The plants, too, should be sprayed at weekly intervals, while they are in the seedbed and in the field as recommended for the control of early blight (page 91).

MOSAIC AND STREAK

The tomato mosaic (caused by a virus or viri) is a serious trouble in most of the older tomato-growing districts where control measures have not been followed closely. The virus causing the disease is the same as the one on tobacco and other closely related plants, not only among the cultivated crops but also among some of the very common weeds.

In the common tomato mosaic, the leaves are mottled with yellow and green and their surfaces are warty. The yellow areas may die and turn brown. The affected plants are dwarfed and usually bear little fruit, although the amount of blossoming may be normal. Occasionally the fruit is affected with russeting, with streaking, or with raised blotches. Plants badly affected in the seedbed may die when set into the field. Later infection never causes death.

A strain of the tomato virus found in plantain may cause a darkening between the lining of the seed cavities and the skin on the fruit, often without showing symptoms on the surface. When held up to the light, the affected part shows a gray cast, so the disease is known as *gray-wall.*

The cucumber mosaic on tomato allows little of the leaf to develop except along the midrib. Therefore this disease is known as *shoe-string* or *filiform leaf.* The leaves near the top of the plant are most conspicuously affected. Plants affected when young usually are much stunted in growth.

The mosaic virus is carried by aphids and other sucking insects, and will live in the soil for two months or possibly longer. The common tomato mosaic virus overwinters in the roots of such hosts as groun cherries (husk tomatoes), horsenettles, jimson weed, night-shade, bitter-

sweet, matrimony vine, and other related plants. The cucumber-mosaic virus lives in the roots of the additional hosts mentioned on page 55. Investigators at various times have tried to show that the virus is carried in the tomato seed, but in America this supposition has not been generally accepted.

Streak is merely another form of mosaic. Dead areas form in the leaves, especially along the veins, and brown streaks appear on the petioles. Light brown, sunken spots, variable in size, may be found also on the fruit. In severe cases the whole plant dies.

One kind of streak can be produced by inoculating the tomato plant with both the tomato mosaic virus and the potato X virus. When the two diseases are together, they seem to be more virulent and kill at least parts of the plants. A second type is produced by a combination of tomato and cucumber mosaics on the same plant. In fact, any other host mosaic that is able to pass over to the tomato seems to cause the disease known as *streak* when it becomes mingled in the plant sap with the ordinary tomato mosaic. There is also a single virus streak, but apparently, if present at all, it is rare in New York State.

Additional virus diseases on tomatoes are Spotted Wilt and Blue Stem or Aster Yellows. These may cause much injury, especially the former when the seedlings are grown in a greenhouse near florist crops. Spotted wilt on the fruit may be mistaken for gray-wall.

Control

The most important control measure is the eradication of the weed hosts near or in the tomato field, and especially those near the seedbed. In addition no flowers should be grown in the same greenhouse where tomato seedlings are produced. Among the more important flower, weed, and other hosts of the viri on tomato are catnip, mother-wort and certain other mints, bur and wild cucumber, ground cherry, horse nettle, milkweed, burdock, petunia, poke weed, calla lily, chick weed, Chinese Lantern, chrysanthemum, wild blue bell, flowering spurge, white cockle, dahlia, Galinsoga, Jerusalem Cherry, sweet pea, Jimson weed, night shade, plantain, tobacco, and potato. If young plants are kept healthy, a fairly large plant may develop before the influence of the disease can reduce the yield much. In the greenhouse it is important also to avoid all tomato refuse in the seedbed, and to remove any mature, living tomato plants in the same greenhouse where young plants are being grown. Since the virus can live in the soil, the seedbed or a new crop in the greenhouse should not be planted for at least four months after the old crop has been removed.

The virus can live for a long while in natural leaf tobacco, and frequently is spread to tomato seedlings with cigarette butts or when the workmen handle chewing tobacco, as well as when ground tobacco stems are added for flea-beetle control.

In greenhouses the mosaic virus is disseminated when the plants are pruned. It has been shown that the later infection is much less common if the workmen occasionally wash their hands with soap and frequently dip their pruning knives into formaldehyde (1 part in 20 parts of water). Breaking out the undesirable shoots in pruning permits less chance of contamination than does cutting. Heavy applications of potash fertilizer in relation to superphosphate seem helpful in reducing mosaic injury.

Seed treatment and spraying have not proved effective in controlling these virus diseases.

POTATO LATE BLIGHT

During a year when potatoes are blighting severely and tomatoes are grown in close proximity, the green tomato fruit and sometimes the foliage may become infected. Rather greasy looking spots (caused

by *Phytophthora infestans)* occur on the green surface. The lesions may be small or cover nearly the entire surface of the fruit. They are not sunken, and the flesh remains firm until secondary rot-producing organisms follow the Phytophthora. When the fruit is cut open, the tissue to varying depths is brown in color.

Control

Tomatoes may be affected some years when late blight is not known to occur on potatoes. Yet it is well to separate the tomato and potato fields by a distance of 10 rods or more. In addition, the sprays suggested for early blight (page 91) should be used if the county agricultural agent sends out spray warnings. Blight and anthracnose spray schedules are discussed on pages 92 and 93. It should be kept in mind that Ferbam or Ziram has almost no effect in controlling this disease and Orthocide 406 is only partly effective, but it easily is reduced in severity by applying any of the coppers weekly or Manzate, Zineb or Nabam at 5-day intervals.

BLOSSOM-END ROT

The first symptom of blossom-end rot is a slight water-soaked area about the blossom-end (caused by undesirable environmental conditions). The lesion soon darkens and enlarges in a constantly widening circle until the fruit begins to ripen. The decaying spot may be merely a speck or it may involve half or even more of the tomato. Sudden lack of water is the principal cause of the trouble. It may be more serious on the windward than on the leeward side of the field.

Control

Inasmuch as blossom-end-rot is so closely related with the water supply, the one important step in controlling the disease is to govern the moisture supply in the soil. The land should be well drained, and plenty of humus should be available to retain the moisture during a dry period. If drought occurs, the cultivating should be very shallow, so that only enough soil is stirred to fill any cracks that may appear and to kill the weeds. Surface scraping even may be preferable. In wet weather, the soil should be stirred enough to cause the evaporation of excess water. Liberal applications of fertilizer high in superphosphate, as 4–12–4 or 5–20–5, also aid in reducing the injury.

In the hotbeds or the greenhouse young plants should not be grown too quickly nor unusually slowly. The plants also should not be subjected to too sudden and severe hardening before planting. A steady growth, both as a seedling and as a plant in the field, will eliminate much of the trouble. The varieties of tomatoes that are most resistant to leaf-blight usually suffer most from the blossom-end-rot. A defoliated plant usually does not have the disease. It, however, has not proved profit-

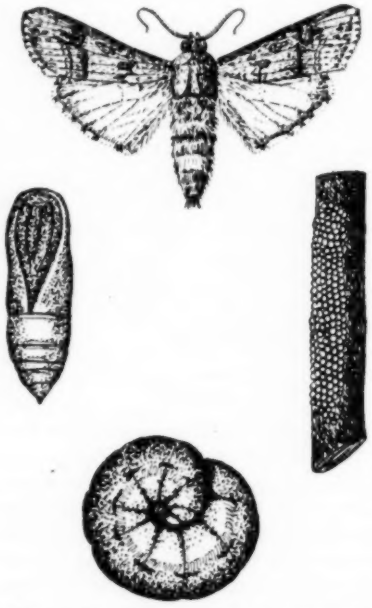


FIGURE 22. FOUR STAGES OF CUTWORM
Top, moth; *center,* pupa (left) and egg mass on a twig (right); *bottom,* curled cutworm

able to remove the foliage in order to protect the fruit from blossom-end-rot.

If irrigation of any kind can be made available, it may prove profitable to use when hot drying winds are blowing. In small, garden plantings partial shading of the vines during dry hot periods and watering with a mist-like spray when hot dry winds are blowing are helpful.

When tomatoes are planted unusually early while the soil is still too cold for growth, the first fruits are likely to be affected by blossom-end rot. Late planting helps to eliminate this form of the disease.

OTHER INSECTS AND DISEASES

CUTWORMS

In some spring seasons, cutworms are a pest. They gnaw at the stems of recently set tomato, cabbage, pepper, and similar plants. In other seasons they are present only in small numbers and their injury is negligible. These worms are easily controlled by good garden practices, including poisoning with a bait mixture.

The insects pass the winter as partly grown worms. They become fully grown in early summer, whereupon they burrow into the soil to a depth of about 2 inches; and there, in an earthen cell, the worms transform to the pupa stage. The moths appear usually in summer, although the variegated cutworm moth appears in early summer and produces a second brood by late summer. The eggs are placed on blades of grass or on sticks, and one moth may lay as many as 500 eggs in one batch or in a group of smaller batches. These hatch within a week or less to produce small inconspicuous cutworms.

Control

By Trapping

In small garden plots cutworms can be located readily in the soil at or near the base of injured plants and can be destroyed. Shingles or small boards placed near the plants will furnish hiding places during the day for the night-feeding cutworms; and at such places the worms can be gathered and destroyed. A stiff paper collar placed around a newly-set plant and sunk a short distance in the soil often prevents cutworms from reaching a plant to feed upon it.

By Poison Bait

A common practice to control cutworms is to scatter a poison bait on the ground, either broadcast or around plants that are being chewed off by the worms. The bait should be applied at sundown because the worms are night feeders; moreover, the bait is less attractive to them when it is dry. Two or three baitings may be necessary to clean up a persistent infestation. The formula is as follows:

	Formula for 2 acres	*Formula for ¼ acre*
Bran	20 pounds	2½ pounds
Paris green	1 pound	2 ounces
Molasses	2 quarts	1 cupful
Oranges or lemons	3 fruits	1 fruit
Water	3 to 3½ gallons	1½ to 2 quarts

Mix the bran and paris green thoroughly. Add the fruit juices to the water. Dissolve the molasses (cheap grade is satisfactory) in the water. Pour the molasses and water mixture over the paris-green-bran mixture and stir to dampen the mash thoroughly. Include the residue of the fruit in a finely chopped condition in the bait.

One pound of sodium fluosilicate or ¾ pound of white arsenic may be substituted for each pound of paris green in the bait formula, since these poisons also have been found effective.

The poison-bait mixture is effective also when scattered broadcast a day or two before the plants are set and after the soil has been conditioned for planting. By this practice cutworms are poisoned in advance of plant setting and injury is often entirely prevented in plots that are regarded as being infested with cutworms.

Control with Dusts

A 5 per cent dust of either DDT or chlordane applied with a knapsack duster on the soil around the base of plants has given good control under field conditions.

It is possible that either of these dusts would control cutworms if they were applied with a row crop duster. The soil should probably not be cultivated for a few days after a dust application.

WIREWORMS

Several kinds of wireworms may injure or kill young plants of melons, cucumbers, tomatoes, and corn when they feed upon the roots or burrow into the stem. These worms are generally a light brown in color and rather hard. They can be exceedingly destructive when they burrow into potato tubers.

Control

When soils are known to be infested with wireworms, and this is likely when the soils have been in sod for some years, they can be controlled by working 6 pounds of actual chlordane (12 pounds of a 50 per cent wettable powder of chlordane) into the top 3 inches of an acre of soil. This must be done in spring before the soil is planted.

When wireworms are working around the roots of young plants a 5 per cent dust of chlordane kills the wireworms if the dust can be worked into the soil close to the plants. Under some conditions, a teaspoonful of this dust can be worked into the soil around each plant and if so it will be found effective.

ASIATIC GARDEN BEETLE

The Asiatic garden beetle (*Autoserica castanea* Arrow) first appeared in this country about 1921. Since that time it has spread to Long Island where it has become a pest of increasing proportions on some vegetables. Its range of injury in this State now includes Westchester and Rockland Counties, metropolitan New York, Nassau County, and the western part of Suffolk County.

Although the beetle is primarily a pest upon flowering plants, it does attack beets, peppers, carrots, eggplant, parsnips, and turnips. Carrots, peppers, and turnips are preferred food plants. Some injury is caused to the roots of vegetable garden plants and grass in lawns by the grub, or immature, stage.

The beetles are most active at night when the temperature is 70° F. or higher. At such times, if present in large numbers, they may devour their food plants. They hide in the ground during the day. They appear late in June and are most abundant between July 15 and August 15. The eggs are laid in the soil from late July through October. The grub stage feeds in late summer and fall on the roots of plants and may develop in large numbers in weedy fields. Their growth is completed in May after further root feeding in spring. The pupal, or resting, stage is in the soil during late May and most of June.

Control

No insecticidal treatments have been made by growers under field conditions to control the beetles when they are feeding upon vegetable crops. It is probable that a dust of 5 per cent DDT or of 5 per cent chlordane would be found effective as the beetles crawl over soil surface treated with either of these insecticides.

There are times in May when well-grown grubs are actively feeding upon the roots of such crops as beets and spinach. To stop such injury, a grower might try to introduce a 10 per cent chlordane dust into the soil at the rate of about 50 pounds per acre in an effort to kill the grubs.

BLISTER BEETLES

Several kinds of blister beetles are destructive at times to beans and cabbage when they appear in large numbers and feed upon the foliage. The immature stages of the beetles develop in ground growing hay crops where they feed upon the eggs of grasshoppers. The beetles are present on grasses or vegetable crops for about two weeks and then return to pastures to lay their eggs in the soil.

Control

The beetles can be killed with a 5 per cent DDT dust or a 1 per cent dust of parathion. Effective sprays are 2 pounds of 50 per cent wettable powder of DDT, or 1 quart of 25 per cent emulsion of DDT, or 1½ pounds of 15 per cent wettable powder of parathion, each to 100 gallons of water.

ROSE CHAFER

A brownish, long-legged beetle (*Macrodactylus subspinosus* Fabr.) measuring about ½ inch in length appears in late June in large numbers at times on cabbage and beans, and its feeding on the foliage may cause injury that needs to be checked. They are present on crops usually for about two weeks. The beetles develop in their immature or grub stages in sandy soils.

Control

This insect can be controlled by the sprays and dusts described for the control of blister beetles (page 99).

GARDEN SLUGS

Soft-bodied animals with a slimy secretion over their bodies and known as *slugs* are occasionally destructive to plants in the greenhouse and in the garden. They are active at night and are found for the most part in cool, moist situations. During the day, except for damp cloudy days, the slugs hide under stone, boards, or debris.

These animals have a rasping tongue-like organ which enables them to feed upon tender plant tissues. When present in large numbers, slugs may ruin completely parts of a young bean field and various seedling plants. They are especially fond of lettuce, radish, cauliflower, cabbage, and tomatoes.

Control

Under some conditions slugs may be trapped in the garden or greenhouse by placing small boards under which they will hide by day; whereupon they can be readily gathered and destroyed. The slugs may be gathered also with the aid of a flashlight or lantern as they feed at night.

A very successful bait has been developed recently which attracts slugs and quickly poisons them when they feed upon it. The poisoning agent is metaldehyde which is mixed with bran or cornmeal in the proportion of seven metaldehyde tablets (28 grams) to each pound (about 2 quarts) of bran. The mixture should be moistened slightly and either broadcasted or placed in small heaps about 2 feet apart. It is effective in gardens as well as in the greenhouse. When used out of doors, it should be broadcasted at the rate of 40 to 50 pounds to the acre in the moister parts of an infested acreage, for the snails are most active in such parts of a field. A number of commercially prepared slug baits containing metaldehyde as the poison are now available at dealers in insecticides.

DAMPING-OFF, BLACK-ROOT, OR WIRE-STEM IN THE SEEDBED

A half dozen or more fungous parasites that cause damping-off are in the soil. They usually grow very near the surface, and enter the plant at the point where the seedling emerges from the ground. All of them require for quick growth a high moisture content of the soil and the air.

Control

If the air and the surface of the soil are kept as dry as is consistent with good growth of the plant, damping-off can fairly well be held in check. If the soil already has some moisture, it sometimes is well to wait 3 or 4 days after the seed is sown before water is applied to the soil. In addition, the seed should be sown thinly enough in the bed so that later the plants will not be crowded. The beds in coldframes should be protected from fog or excessive rain. If the soil in the bed is heavy and slow-drying, it can be im-

proved by mixing with it a small amount of sand or by sprinkling sand over the surface. The watering should be done in the morning and preferably on bright days. Heavy applications of water at long intervals are more desirable than are frequent light sprinklings. Stirring the surface soil after an application of water helps it to dry and thereby reduces the chances of damping-off. The pitch of coldframe sashes should be at least 45 inches to prevent excessive leakage, and the glass panes as large as the market affords. Broken panes should be replaced and all sashes well puttied.

Correct conditions cannot always be maintained, particularly in hotbeds or in low greenhouses. Soil sterilization with quick direct heat, steam, formaldehyde, or chloropicrin is recommended if also other diseases or weed seeds are to be combated.

Copper compounds or formaldehyde will quickly kill certain damping-off fungi. Corrosive sublimate too is very toxic to all the damping-off fungi that have been tested so far, including Rhizoctonia, but is sometimes injurious to crops especially those not related to the cabbage family.

The hot-water treatment of crucifers (page 33), tomatoes (page 91), eggplant (page 58), and spinach (page 79) helps materially to reduce damping-off.

One ounce of corrosive sublimate (mercuric chloride) is dissolved in a little hot water and then diluted to 15 gallons. One pint of this solution may be applied to each square foot of soil at seeding time. There is danger of seed injury, therefore a test should be made before large areas are treated to make sure that the conditions and the nature of the crop will permit the use of mercury compounds. Cabbage, cauliflower, and brussels-sprouts seedbeds are treated with the corrosive sublimate by applying in a thin stream along the base of the plants 1 pint for each 4 feet of row when plants are small, and 2 feet when they are large. A wheelbarrow type of applicator can be made of spare farm implement parts. Two or three weekly applications usually are enough.

Various organic-mercury compounds that have been used successfully by some growers are on the market. These compounds should always be applied according to the directions on the containers.

In the liquid copper treatment, 2 ounces of blue vitriol are dissolved in 1 gallon of water, and the seeds, after being tied loosely in cheesecloth, are soaked in this solution for an hour or more. After this treatment, the seeds are removed and dried, or blotted with newspapers, and are then mixed with dry sand so that they may be handled readily; they should be planted immediately. They are not washed with water after immersion in the copper solution. This liquid treatment applies especially to tomatoes, beets, spinach, and squash seeds.

The dust treatments are with zinc oxide, Arasan, Semesan, Phygon, Orthocide 406, Tersan, or Spergon. One level teaspoonful or less of the dust is shaken thoroughly with 1 pound of seed. These treatments have proved especially successful on tomato, spinach, beet, peppers, and eggplant, and have been satisfactory on a number of other vegetables and flower seeds.

In hotbeds, coldframes, and greenhouses, the treating of the seed with dust may well be supplemented by spraying the plants with one of the insoluble copper compounds, 4 pounds in 100 gallons of water (2 ounces in 3 gallons), with Ziram, 2 pounds in 100 gallons (1 ounce in 3 gallons) or with Orthocide 406 at the same strength. The suspension should be kept well agitated. The applications are made at four- to seven-day intervals, beginning when the plants break through the ground. The spray should be made to run down the stems of the plant and wet the soil at the base of the stem. Midget power sprayers that can be drawn through the aisle of a greenhouse and that apply the spray quickly and easily are on the market. Where the size of the plant beds justifies the expense, few investments pay better

in results and satisfaction than one of these greenhouse power sprayers.

If formaldehyde is used, 2.5 tablespoonfuls of the 40 per cent strength is applied to each bushel of soil, or 1 tablespoonful to each flat or 2.5 square feet of bed. The formaldehyde is diluted with 5 or 6 parts of water, sprinkled uniformly over the soil and thoroughly mixed into the surface. The treated soil or flats are left standing for 24 to 48 hours before the seeding. After the seeds are sown, the soil should be wet down well. The fumes present at seeding time help to disinfest the seed so that no other seed treatment is necessary. But after the plants are up, they may be sprayed with an insoluble copper suspension mentioned in the above paragraph.

In some States, sand-culturing for the control of damping-off is popular. As nearly pure sand as is available is placed in shallow tight containers and flooded with hot water (160° F. or hotter). The sand is stirred so that organic material is dissolved or floats. The water is then poured off. The washing is repeated until the water remains practically clear. The number of washings depends upon the purity of the sand. Unused clean sand may not require hot water for washing. The sand then is placed in clean flats, and just before planting is moistened with a water solution containing 3 grams of potassium nitrate for each flat or 2 grams for each square foot (approximately ⅔ ounce for each square yard). The seeds then are sown and cared for in the usual way. When ready for transplanting the flat can be placed in water and the seedlings picked out without breaking the roots. Most of the sand in the western part of the State contains deleterious substances and cannot be used for growing seedlings.

ROOT-KNOT OR NEMATODE INJURY

The nematode, or eel-worm (caused by *Heterodera marioni*) causes swellings on the roots of nearly all vegetables and many other plants. The swollen roots later decay. If infection occurs when the plant is young, the reduction in food intake from the soil becomes so great that the plant may die. Later infections dwarf the stem and leaves, and reduce the yield. Among the more seriously affected crops are cucumbers, muskmelons, squash, watermelons, pumpkins, tomatoes, eggplant, tobacco, caraway, coriandrum, cumin, okra, petunia, snapdragon, lettuce, spinach, parsley, fennel, carrots, parsnips, celeriac, and celery. Among the less susceptible plants are beets, asparagus, cabbage, kale, turnips, radishes, onions, peas, beans, and potatoes. Most grasses and cereals are almost immune except under special conditions.

Root-knot is caused by a minute worm-like parasite that is too small to be seen by the unaided eye and which under favorable conditions (80° to 85° F.) multiplies very rapidly. One female may lay from 500 to 1000 eggs, and a life cycle may be completed in 24 days. The organism generally is present wherever the winter temperatures remain relatively high. In New York the trouble is rarely severe except where the nematodes have the opportunity to live over winter in a heated greenhouse, for they lie dormant below a temperature of about 57° F. When plants from such a house are set into the open field, the parasite may already have entered the young rootlets or be harbored in the soil clinging to the plants. If the crop is a susceptible one, the eel-worm multiplies rapidly. Should the following winter be mild, and a second susceptible crop such as carrot, lettuce, or celery be planted, the yield of the entire field may be destroyed or at least greatly reduced. On the other hand, in winters when the temperatures fluctuate rapidly and extremely, so that the soil freezes and thaws several times, the organism is partly if not wholly eradicated. Root-knot is worse in loose sandy soil or muck than in heavy clay.

CONTROL

In this State the most practical method for field control of root-knot is to grow for two successive years fairly resistant crops such as cereals (including corn), grasses, onions, potatoes, cabbage, or beets. It is better in these two years to grow some crop from seed planted directly into the field, otherwise the young transplants may again carry the pathogen from the greenhouse or hotbed.

It is necessary also to disinfest the greenhouse soil with heat or with some effective chemical.

A full discussion of the subject, soil disinfestation, would make a long bulletin within itself. Therefore, it is suggested that any grower who is interested in this method of nematode control, discuss with his county agricultural agent the advantages and disadvantages of the following: flash-flame sterilizer, steam pan, steam pipes, electric pasteurizer, formaldehyde, Chloropicrin, and other chemicals. If still further knowledge is desired, a number of publications on the subject can be found in the Plant Pathology Departments at Geneva and Cornell.

In the heat treatments, the soil should reach a temperature of at least 160° F. for ten minutes. Among the best volatile fumigants are chloropicrin, DD mixture and certain solutions containing methyl bromide or ethylene dibromide (Iscobrome D or Dowfume W–40). In both heat and chemical treatments, the aisles and spaces in front of each door should be disinfested as carefully as are the beds. Recently a number of other chemicals have been tried and some of the cheaper ones appear promising.

INSECTICIDES AND FUNGICIDES

ARSENATES

In general, arsenates are not used on most vegetable crops because of the harmful residues of lead and arsenic on such crops as cabbage, cauliflower, and beans at harvest. Lead arsenate may be used on late or domestic cabbage when it is to be sold in a closely trimmed condition, which should eliminate the danger of lead-arsenate poisoning. The arsenates should not be used on early grown green cabbage except possibly in the absence of rotenone or pyrethrum, and, if used then for worm control, the outer leaves should be removed before the cabbage is marketed.

NICOTINE

For spraying purposes, nicotine is usually sold in the form of nicotine sulfate containing 40 per cent of nicotine. The recommendations in this bulletin are based on a product of that strength. Nicotine sulfate is not volatile, but the fumes of the nicotine are liberated when the material is applied as a spray in combination with soap for a quick kill. Nicotine sulfate is not effective enough when mixed with water only. It is not so effective in combination with bordeaux mixture as when used with soap.

A table showing the proportions of water and nicotine sulfate to obtain different quantities of spray at different dilutions follows:

If the nicotine-sulfate spray is not to be combined with other spray ingredients such as bordeaux mixture or arsenates, from 1 to 2 ounces of soap is added for each gallon of the spray up to 10 gallons; from 2 to 3 pounds for each 100 gallons of spray.

For greenhouse use, nicotine is often sold in the form of a 40 per cent solution, the nicotine being in the "free," or uncombined, form.

Nicotine dust is usually made by mixing nicotine sulfate with hydrated lime. Nicotine-lime dusts can be bought ready-mixed, or they may be prepared at home in a ball mixer or in a self-mixing duster. The purchaser should be sure that the

Amount of nicotine sulfate spray to be mixed	Amount of 40 per cent nicotine sulfate to use for			
	1–200 strength	1–400 strength	1–600 strength	1–800 strength
1 quart	1 teaspoonful	½ teaspoonful	⅓ teaspoonful	¼ teaspoonful
1 gallon	4 teaspoonfuls	2 teaspoonfuls	1⅓ teaspoonfuls	1 teaspoonful
10 gallons	7 ounces	2½ ounces	2 ounces	10 teaspoonfuls
100 gallons	2 quarts	2 pints	1½ pints	1 pint

nicotine-lime dust has been kept in a tight container, since it loses its nicotine strength when exposed to the air.

Fixed nicotine dusts containing 3 per cent nicotine are also available. These are especially useful against aphids.

STICKERS AND SPREADERS

In most instances it is advisable, if not necessary, to incorporate a spreading and sometimes a sticking agent in a spray mixture. This is true especially when smooth foliage plants, such as onions and cabbage, are to be sprayed. Such spreading agents may have a substance that causes the spray to adhere or stick to the foliage in spite of rain or heavy dews. Others help to deposit the spray material uniformly on the plant foliage and are an additional killing agent.

A dilution of potash-fish-oil soap, cocoanut-oil soap, one of the milder powdered soaps, or powdered skimmilk is often added to spraying solutions as a spreader.

The newer detergents or synthetic washing powders also act as good wetting agents when added to suspensions or solutions of most insecticides.

The soaps can be used with nicotine-sulfate sprays at the rate of from 3 to 5 pounds per 100 gallons, but they should not be used with arsenical sprays. Skimmilk powder, such as calcium caseinate, is a fairly good spreader for rotenone-powder sprays. About 2 pounds usually are used with 4 pounds of 4 per cent rotenone powder in 100 gallons of water.

Proprietary spreaders are often used in place of soap and casein spreaders. They should be used according to manufacturers' directions.

With DDT wettable powders or DDT emulsifiable solutions, enough of a wetting agent may not be incorporated in them to wet the plants, such as onions, cabbage and like plants, when they are used at a suggested dilution on one crop and at the same dilution on another crop. Such inadequate wetting may be corrected by adding a small amount of a proprietary wetting agent to the tank before the DDT is added. Enough should be included to give good wetting, but not an excess that would cause run-off on the plants.

ROTENONE-BEARING INSECTICIDES

Rotenone is one of the poisonous insecticides effective against insects and other cold-blooded animals, but non-poisonous to man in quantities as applied to crops to control insects. Rotenone itself is found in the roots of derris, timbo, and cubé. In the form of powdered roots it is widely used on vegetable crops infested with insects in place of the poisonous arsenates. It also has a deterrent effect against some insects.

The strength of a rotenone-bearing insecticide is based upon the amount of rotenone in it, although other chemical properties in the insecticide may also exert a slight or moderate toxic effect upon the insect to be controlled.

Rotenone is sometimes combined with DDT or pyrethrum in either the dust or spray form so that the mixture will kill two or more kinds of insects that may be on the plant at the same time. An example is the bean beetle and leafhopper on beans. If insects such as the Colorado potato beetles and cabbage worms show resistance to DDT, rotenone will likely be

recommended as an additive in an effort to get good insect kills.

Rotenone Dusts

Most of the ready-mixed rotenone dust insecticides now available on the market show an analysis of ½, ¾, or 1 per cent of rotenone. The stock ground root, unmixed with a carrier like clay or talc, sulfur or tobacco stems usually contains 4 or 5 per cent of rotenone. A vegetable grower should procure and apply dust of the proper strength of rotenone recommended for a given insect.

All dusts containing rotenone should be kept in tightly closed containers; otherwise they lose some of their strength. Rotenone dusts carried over the winter to another season are likely to lose a small part of their toxicity, but such loss usually can be offset by making somewhat heavier applications on the crops than would be made with dusts having their full rotenone strength.

For such insects as the corn borer and the squash vine borer a rotenone dust of 1 per cent strength is recommended. Where rotenone dust is advised for other insects such as flea beetles, green cabbage worms, bean beetles, and the like, a ¾ of 1 per cent strength is advised. Sometimes a dust mixture containing ½ of 1 per cent rotenone is just as satisfactory as a ¾ of 1 per cent rotenone dust, because the difference in rotenone content can be offset by more thorough application.

Rotenone Sprays

Growers who prefer to apply rotenone as a spray must purchase a ground root with an analysis of 4 per cent of rotenone and use 4 pounds to 100 gallons of water. If a ground root with a 5 per cent rotenone content is purchased, about 3½ pounds are used per 100 gallons. A spreader and sticker are always helpful, especially on waxy-leafed plants like cabbage, and a sulfonated oil, or powdered skimmilk or one of the many proprietary spreaders and stickers now on the market should be used. From 2 to 3 pounds of powdered skimmilk are usually used in 100 gallons of spray. Proprietary spreaders and stickers should be used in accordance with directions on the container.

Spray concentrates containing rotenone extract are now available where insecticides are sold. They contain from 2 to 5 per cent of rotenone. Some of these synthetic sprays contain chemicals other than rotenone extract which have insect toxicity in themselves. In some of the synthetic spray concentrates, the rotenone extract is synergistic with other chemicals in the concentrate. Pyrethrum extract or a solution of DDT may be included in small quantities in a rotenone-extract concentration to kill more kinds of insects or to give the spray a more lasting effect. These sprays usually are effective against aphids, flea beetles, cucumber beetles, and cabbage worms. The synthetic sprays containing rotenone extract should be used according to manufacturers' directions. The dilutions vary from 1 to 300 to 1 to 800, depending upon the insecticide and the insect to be killed. These sprays like the rotenone powder sprays kill insects by contact; hence thorough wetting of the insect is necessary.

Compatability of Rotenone

Rotenone dusts are compatible with sulfur or insoluble copper dusts. They should not be used with lime.

Rotenone sprays are sometimes used with insoluble copper compounds and with bordeaux mixture. With bordeaux mixture the toxicity of the rotenone is likely to be reduced somewhat if the lime content of the mixture is high. When combined with bordeaux mixture, the rotenone powder or extract should be added last and the mixture applied immediately. Soap is never added as a spreader to a rotenone spray. Proprietary spreaders usually are compatible with rotenone sprays, as is calcium caseinate.

PYRETHRUM

Pyrethrum is one of the insecticides non-poisonous to man prepared from flowers of the pyrethrum plant. The pyrethrins in the flowers are the elements that are toxic to insects. They kill insects by paralyzing them when the pyrethrum in a spray or dust form is brought in contact with their bodies. Pyrethrum loses its killing power very soon after it is exposed to air and light. Pyrethrum insecticides are sold as extracts and as dusts.

Pyrethrum Sprays

Pyrethrum sprays are sold as extracts in a spray concentrate which is diluted with from 400 to 1000 parts of water and is then ready for use. In these concentrates the pyrethrum extract is dissolved in a carrying agent, and the resulting synthetic spray compound is readily dispersible in water. The concentrates may have a small amount of rotenone extract included so that the spray will be effective against more kinds of insects. These sprays are somewhat costly but they are effective against such insects as cabbage worms, including the looper; Japanese beetle; squash bugs; plant lice; rose chafers; bean beetles; leafhoppers; and blister beetles. The sprays should be used according to directions supplied on the container.

Pyrethrum Dusts

Dusts containing pyrethrum as a toxic agent are of two kinds. One is composed of ground pyrethrum flowers which have been activated with a small amount of pyrethrum extract and then mixed with a carrying agent, such as talc, pyrophyllite or clay, and occasionally some sulfur. It is known as an *activated* dust, and usually contains from 0.06 to 0.09 per cent pyrethrins in the finished dust. A second type is known as an *impregnated* pyrethrum dust. In this mixture, pyrethrum extract is worked into a small amount of a carrying agent, such as talc, and the resulting mixture is then added to a bulk of a carrying agent or clay diluent. This impregnated type of dust usually contains a smaller amount (from 0.03 to 0.04 per cent) of pyrethrins but, because of its method of preparation, it is sometimes considered the equal of the activated dusts or the ground flowers dust that contain from 0.06 to 0.09 per cent pyrethrins.

The pyrethrum dusts are effective against insects listed under pyrethrum sprays and they may often be substituted for rotenone dusts. Because they lose their strength rather rapidly within three months of their processing, a grower should make every effort to purchase dusts that are freshly mixed. These dusts may lose half of their effectiveness if carried from one season to another.

DDT

The insecticide DDT, abbreviated for dichloro-diphenyl-trichloroethane, has a place in vegetable-insect control where treatments can be made to prevent a harmful residue on the crop after it is prepared for table use, or when ready for sale on the market. It must be regarded as a poison. It is a deposit type of insecticide, and insects affected by it die if they persist in crawling over it or otherwise come in contact with it. Hence new growth of foliage must be kept covered with DDT during the period the insects are present.

Because it is a poison, it should be used with care and judgment. Treatments with it do not need always to be heavily applied; for example, a 1 or a 2 per cent DDT dust is often as effective as a 3 per cent DDT dust. The stronger the dust, the greater the amount of DDT residue one is likely to find on the plants; this residue must be prevented on leafy vegetable crops. On young plants, however, or on vines such as potatoes, or on corn and peas (stalks and vines of which are not to be fed to livestock), heavier treatments of DDT may be allowable.

Precautions need to be taken also to

wash the exposed parts of the body after using DDT. The inhaling of excess amounts of the dust or fine spray should be avoided, and a respirator is advisable if one is exposed to the dusts for any length of time.

Sprays and Dusts

Sprays of DDT are made with wettable powders that mix readily in water, and with emulsifiable solutions of DDT that are added to water. The wettable powders may contain 50 or 75 per cent of DDT. In general they are used at the rate of: 2 pounds of 50 per cent DDT wettable powder or 1⅓ pounds of the 75 per cent powder to 100 gallons of water.

The emulsions are used at a dilution of about 1 to 400, or 1 to 800 and this is at the rate of 1 pint to 1 quart of a 25 or 30 per cent emulsion to 100 gallons of water. The wettable powders or the emulsion may be added to bordeaux mixture or other copper sprays if this is desirable. From 100 to 150 gallons of the spray should be applied at each treatment to an acre of row crops. When equal pounds of DDT in a wettable powder and an emulsion are compared, the emulsions of DDT are more effective.

DDT solutions in kerosene or similar oils that cannot be mixed in water should not be used on vegetables or like foliage as the kerosene is likely to burn foliage. DDT solutions are intended primarily as deposit sprays to control flies and some household insect pests.

Dusts of DDT contain 3, 5, or 10 per cent of the insecticide, and the remainder is filler or perhaps some copper or sulfur as a fungicide. They may be of the impregnated type and thus contain as little as one-half of 1 per cent of DDT. They may have some rotenone or pyrethrum or parathion included, with the expectation that the added insecticides will produce an immediate kill of some insects while the DDT has more residual effect. The dusts are used at the rate of 20 to 35 pounds an acre, the amount depending upon the size of the plants to be treated, and the efficiency of the dusting machine used.

The dusts should be as effective as the sprays unless they should weather or be washed from the foliage more and quicker than the sprays. In general, a 1 or 2 per cent DDT dust is used on vegetables. A 3 per cent dust is used on potato foliage, a 5 per cent dust is used on some fruit trees, and a 5 or ten per cent dust is used in household insect control.

DDT kills slowly. Hours or even a day or two must be allowed for DDT to kill most insects. Two days may be required for it to kill a flea beetle. A few hours only are needed to cause a leafhopper to die. Immediate kills, such as are caused by pyrethrum or rotenone, must not be expected. Once insects are affected by DDT, they are not likely to continue feeding upon the treated foliage.

DDD AND METHOXYCHLOR

DDD and Methoxychlor are closely related to DDT, the chemical formula having been altered in such a way that they are not so toxic to warm blooded animals as is DDT. This alteration has, however, also made them somewhat less toxic to some insects on a pound for pound basis. Both are formulated as dusts, wettable powders, and as emulsions.

They have found some usage in New York for the control of cabbage worms, cucumber beetles, and the Mexican bean beetle. They are not generally available in the State.

BENZENE HEXACHLORIDE

Benzene hexachloride, is commonly known as *BHC*. It is effective against many kinds of insects, but especially against wireworms in the soil and against plant lice. An objection to it is its odor, but manufacturers have removed most of that to produce the pure gamma form of BHC known as *lindane*.

The strength of toxicity of BHC is always indicated on the label by the amount of its gamma isomers. It may contain in dust or spray forms from 1 to 6 per cent of the gamma isomer.

Benzene hexachloride stunts some vine crops. When used in the soil even in small quantities to control wireworms, an objectionable odor and flavor has usually been imported to the potato tubers grown in the soil following an application of this insecticide. It has been added as a 2 per cent gamma strength to a DDT dust for use on cabbage to control aphids and worms. The control was quite satisfactory, but an objectionable flavor was noted on the cabbage if the dust was applied within four weeks before the cabbage was used.

CHLORDANE

Chlordane is the common name for a chlorinated hydrocarbon compound that has shown a high degree of toxicity against many kinds of insects. It can be used as an emulsifiable concentrate solution containing from 42 to 72 per cent of the toxicant, as a wettable powder, as a dusting powder, or in an oil solution.

It has been found effective against wireworms in the soil, and against such insects as grasshoppers and cutworms. It is effective against cabbage and onion maggot and certain leaf mining insects which have been difficult to control heretofore with any other insecticides.

As a 5 per cent dust it is effective against the cabbage maggot when applied on the soil around the base of cabbage and like crops. To control this insect, it can be used also in the setting water or in the fertilizer when the plants are being set in the field.

At dosages used to kill insects, chlordane appears to be safe on the foliage of most plants. It has some residual effect. It is reported that it does not impart any objectionable flavor or odor to vegetables upon which it might be used.

Chlordane is also one of the insecticides used together with a fungicide as a coating on seeds such as beans and corn to control maggots and wireworms on sprouting seeds.

ALDRIN AND DIELDRIN

Aldrin and Dieldrin are related to chlordane. They belong to the hydrocarbon group. They have considerable residual action. Both have shown much promise in the control of subterranean insects because they have notable fumigating action when used in the soil.

Aldrin and dieldrin have been tested rather extensively on an experimental basis recently as dusts, wettable powders, and emulsions. Both show much promise in the control of some insects even though used in dosages of as little as ½ pound of the active ingredient per acre.

DILAN

Dilan is a dinitro-chlorophenyl type of insecticide. As a vegetable insecticide it appears to have usage in the control of the Mexican bean beetle. Its use is still in the experimental stage.

TOXAPHENE

Toxaphene is a chlorinated camphene type of insecticide. It is especially effective against cutworms, armyworms, and grasshoppers. It is sold as a dust, a wettable powder, and an emulsion.

PHOSPHATE COMPOUNDS

Since 1948 there have appeared on the market a group of insecticides known as *phosphate compounds*, which have proved most effective in killing many kinds of insects. Nearly all have one objection — they are hazardous to the one applying them and must therefore be used with much caution.

Some, such as HETP and TEPP, have little or no residual effect; others such as parathion, Potasan, and Metacide have residual action of four to seven days against some insects. Still others, such as

Systox and Pestox–3 have a systemic action in addition to giving quick kills of some insects; that is, they are absorbed by the plant tissues when sprayed on the plant, and by this action, they serve to kill some kinds of aphids and mites when they invade the sprayed plants to feed upon them. Some are regarded as having a fumigating as well as a contact action.

Of these, TEPP and parathion now have wide usage in vegetable insect control. They are available as 1 per cent dusts, or as wettable powders, or as emulsions. The active ingredient varies with the processor's product, hence label directions should be followed when they are being diluted for spraying.

Potasan, Metacide, Systox, and Pestox–3 are now being tested on a field experimental basis. It is likely that they, too, will find wide usage in insect control.

It is again pointed out that sprays or dusts of these phosphate compounds can readily be absorbed through the skin in toxic quantities, and perhaps fatally so, if the user is careless. They are highly toxic when taken orally. Their vapors or fumes can be very harmful. When they are used, the skin should be well protected and a respirator should be worn. The manufacturer's directions should be followed closely.

INSECTICIDES AS POSSIBLE HARMFUL RESIDUES

Vegetable growers should always remember that an excessive use of some of the recently developed insecticides may leave a residue deposit of the chemical at harvest, which may be toxic to the persons consuming the product. Moreover, they may leave residues in the soil in such a quantity that root crops like carrots or beets could absorb some of the insecticides if planted in the soil the following year.

The important canning crops industry of New York is strongly averse to purchasing some crops treated with some of these newer insecticides; nor are they likely to purchase them if grown a year later in soil treated with some of these pesticides. A grower raising canning crops should keep in touch with the policies of the canning industry. Helpful guidance may always be obtained from the county agricultural agent.

To determine whether harmful residues are present in the soil or on marketable vegetables and fruit, the Cornell and Geneva departments of entomology of the College of Agriculture conduct extensive field tests and laboratory chemical analyses. Attention is given also to possible off-odors or off-flavors which a pesticide may produce. The canners, insecticide manufacturers, and federal workers cooperate closely with the entomologists in this work. It is largely on the basis of such work that recommendations are then made.

BORDEAUX MIXTURE

A very frequent spray used on vegetables is bordeaux mixture. This is made by mixing a solution of copper sulfate (blue vitriol) with milk of lime. A mixture made from 4 pounds of copper sulfate and 2 pounds of lime to 50 gallons of water is indicated by the formula 4–2–50; 5 pounds of copper sulfate and 2.5 pounds of lime to 50 gallons of water, by 5–2.5–50, and so on. Bordeaux mixture of any strength is made as follows:

A stock solution of copper sulfate is made in a barrel from 50 pounds of copper sulfate dissolved in 50 gallons of water. If the crystals, placed in a gunny sack, are suspended just beneath the surface of the water, they will dissolve in the course of three or four hours.

A stock mixture of lime is made by mixing 25 pounds of hydrated lime in 50 gallons of water. Some investigators prefer 25 pounds of freshly slaked burned lime in place of the hydrated material. Air-slaked lime or hydrated lime that has become partly air-slaked should not be used.

The sprayer is filled three-fourths full of water. If a 4–2–50 solution is desired, 4 gallons of copper-sulfate stock solution is added to this water for every 50 gallons

of mixture to be made. The solution requires stirring until it is well diluted, after which 4 gallons of the stock mixture of milk of lime is added to each 50 gallons of the mixture. The lime water is run through a strainer to prevent the larger particles of lime from getting into the spray tank. While the milk of lime is being added to the dilute copper-sulfate solution in the sprayer tank, the material in the tank should be stirred constantly. The sky-blue bordeaux mixture will result. Enough water to make the required amount of mixture must now be added. The milk of lime may be added first if desired. An insecticide may be added to the bordeaux mixture if insects are to be controlled. For making small quantities of the fungicides, 4 ounces of copper sulfate, 2 ounces of hydrated lime, and 3 gallons of water are necessary.

If only a small amount of the spray material is required, 4 ounces of blue vitriol are dissolved in 1½ gallons of water. In another container 2 ounces of hydrated lime are mixed into 1½ gallons of water. The two mixtures are then poured together slowly, being stirred vigorously during the mixing.

LOW-SOLUBLE COPPERS

The copper oxides are very high in metallic copper content, ranging from 86 to 92 per cent or more. They also have been produced in extremely small particle size. These two facts make them good fungicides but may also add to their injury to plants. Red cuprous oxide, when available, is excellent for seed treatments, especially of eggplant, pepper, spinach, and beet, but the others are so toxic that usually they are not recommended for seed treatments unless the grower is familiar with them and applies the dusts with extreme care. They are used in sprays or dusts on field plants. In dusts they should be applied in a 6.0 per cent strength, and in sprays with 1.75 pounds of metallic copper for each 100 gallons of water.

The copper oxychlorides usually range in metallic content from 25 to 56 per cent. In general, they are less injurious to plants than are the oxides and at the same concentrations are not quite so good fungicides. They can be applied to most vegetable seedlings and in the field to any of the crops that require copper protection. In dusts they are applied at 6 to 7 per cent metallic copper concentration and in sprays at 2 or 2.5 pounds of metallic copper for each 100 gallons of spray. In most communities the dusts can be bought already prepared.

ORGANIC FUNGICIDES

Ziram (zinc di methyl di thio carbamate). This includes the trade names, Zerlate, Opalate White, Corozate, Karbam White, Methasan, and others. It is applied as a spray (2 or 3 pounds in 100 gallons of spray) or as a dust (10 pounds in 90 pounds of inert material). On older plants it should be used with a sticker-spreader. It may cause injury to roses, apples, and other rosaceous plants.

Ferbam (ferric di methyl di thio carbamate). This represents Fermate, Karbam, Nu-Leaf Black, Ferradow, Coromate, and others. It also is used as a spray or dust in the same manner as suggested for Ziram. It should not be applied to young delicate seedlings nor to such tender plants as muskmelons. It causes no unsightly spotting of green or red fruits nor of foliage so is recommended for roses and fruit trees.

Zineb (zinc ethylene bis di thio carbamate). Parzate, Dithane Z-78, Ortho-Zineb, and others. It is applied as recommended for Ziram but cannot be used on delicate seedlings. When applied twice a week, it is effective against the downy mildews (including late blight of tomato).

Nabam (di sodium ethylene bis di thio carbamate). Dithane D–14, liquid Parzate, Ortho-Nabam, Thiodow, and others. This is sometimes used in its

original form to treat potato tubers before planting. In sprays, 0.5 to 1 gallon is diluted with 100 gallons of water to which 0.5–1 pound of zinc sulfate has been added. This really changes it to one of the Zineb type.

Thiram (tetra methyl thiuram di sulfide). The wettable form is known as Tersan which is used for treating seeds (page 67) or for dusting (page 63). The non-wettable form is known as Arasan and is used widely in dusting seeds to control damping-off. It is applied especially to bean, lima bean, beet, spinach, sweet corn, swiss chard, and tomato seeds. Special forms, Arasan SF and SF-X, are sold for the slurry method of treating seeds, and can be used as a dust treatment.

Spergon (tetra chloro para benzo quinone +1 per cent phosphate). The powder form is used for dusting seeds to control seed rot and damping-off. It has the added advantage of being a lubricant so treated seeds pass through the drill without friction and are not damaged so much as are untreated seed. The material is applied especially to beans, lima beans, peas, cucurbits, and others. It is not inclined to cause injury. Large seeds require ½ level teaspoonful for each pound or 2 ounces per bushel, while small vegetable seeds require twice that amount. There also is a wettable form used in sprays or dusts (see downy mildew of cabbage). A form of it is applied also by the slurry methods for seed treatments.

Orthocide 406 (recently named also "Captan") (N–trichloro methyl thio-tetrahydro-phthalimide). This has proved effective in treating vegetable seeds by the dust method (as recommended for Arasan) and for spraying plants in the field. The concentrations of spray have not yet been well established, but 4 pounds in 100 gallons of water is suggested.

Manzate (manganese ethylene bis di thio carbamate). This is an excellent fungicide on many crops, and is especially effective against anthracnoses and, when applied at five-day intervals, will also control downy mildews (such as potato late blight on tomato).

Each of the other fungicides named in this bulletin is sold in only one form and under a distinctive name. They are used according to the directions given under the respective vegetable diseases.

A publication of the
New York State College of Agriculture,
a unit of the State University of New York,
at Cornell University

Published by the New York State College of Agriculture at Cornell University, Ithaca, New York. L. R. Simons, Director of Extension. This bulletin is published and distributed in furtherance of the purposes provided for in the Acts of Congress of May 8 and June 30, 1914.